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(57) Abstract

The present invention relates to an omniramic wide angle optical system which is associated with a camera, projector, medical instrument, surveillance system, flight control system, or similar article. The optical system typically consists of a Cassegrain system having a strongly curved convex reflecting surface with a prolate aspheric figure, a secondary reflector surface, and a modular imaging and correcting lens system.

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Jeffrey R. Charles, Inventor. PCT Patent Application for:

OMNIRAMIC OPTICAL SYSTEM HAVING CENTRAL COVERAGE MEANS WHICH IS ASSOCIATED WITH A CAMERA, PROJECTOR, OR SIMILAR ARTICLE

To the Commissioner of Patents and Trademarks:

Your petitioner, Jeffrey R. Charles, a citizen of the United States and a resident of Pasadena, State of California, whose post-office address is 2454 East Washington Blvd., prays that letters patent may be granted him for the improvement in an Omniramic Optical System Having Central Coverage Means Which Is Associated With A Camera, Projector, or Similar Article, set forth in the following specification.

This application claims the benefit of U.S. provisional application serial number 60/043,701, filed April 16, 1997. Further, this application claims the benefit of U.S. provisional application serial number 60/055,876, filed August 15, 1997 for claims specifically referenced thereto. Still further, this application claims the benefit of all specified prior art which was originated by the applicant and published less than one year prior to the present application. Yet further, this application claims the benefit of all prior art which was originated by the applicant and is verifiably documented by other means, including his prior U.S. design patent D312,263. All claims not specifically supported in provisional application serial number 60/043,701 are so noted herein. This application primarily addresses drawing sheets originally numbered 1, 2, 4, 7, 8, and 9 in U.S. provisional application serial number 60/043,701, Filed April 16, 1997.

Additionally, this application references all appropriate elements of U.S. provisional application serial number 60/043,701, filed April 16, 1997, including forms such as the verified statement claiming small entity status, information disclosures, the filing date; copies of prior art references, descriptions, drawings, remarks, and all other related elements for the purpose of covering any errors or omissions which may exist herein until such a time as he is requested to remove said references or material by an examiner or other duly authorized patent personnel for purposes such as formality, or until or unless he otherwise requests its removal. Further, if it is permitted, the applicant specifies that the entirety of the accompanying document entitled "Cover Letter, Introductory Remarks, Details Relating to Prior Art Information Disclosure" is considered part of the specification of this application for the purpose of covering any errors or omissions which may exist herein until such a time as he is requested to remove it by an examiner or other duly authorized patent personnel for the purposes such as formality, or until or unless he otherwise requests its removal. In general, material in the accompanying document is intended to assist the examiner during examination of this application and it includes substantial material which may otherwise be in a response to an examiner's action, where said action may be based on said examiner not being privy to information therein; however, it is not necessarily intended as permanent text for the patent as hopefully issued, so said accompanying document is provided as a separate (and separately numbered) document to facilitate the removal of some or all elements therein from the present specification in a way which is easy to communicate. The specification herein includes page numbers at the top of each page; however, said page numbers are not intended to be part of said specification text, so they are printed outside the specified one inch top margin. Some or all of this paragraph is not intended to be part of the final specification either; except for allowable elements herein which reference other material. Therefore, elements of this paragraph which are informal or otherwise not required in this specification shall presumably be removed prior to the issue of any resulting patent.

BACKGROUND OF THE INVENTION

The present invention relates to a wide angle optical system providing means for the simultaneous and seamless imaging of the entire great circle perpendicular to its optical axis, also encompassing a wide angular area on either side of the plane of said great circle. More particularly, the invention relates to an imaging system which typically includes reflecting and refracting optics, said optics having providing means for the geometric conversion of three dimensional space surrounding the invention into a two dimensional annular image or vice versa; which is associated with or incorporated into a camera, projector, medical instrument, surveillance system, robotic system, flight control system, simulator, or similar article. Images produced or projected by the invention are applicable to many fields, including ordinary or full motion indoor and outdoor panoramic photography with various format cameras; omniramic and omnidirectional recording of subjects for virtual reality applications with a film camera, electronic camera, or similar article; omniramic or omnidirectional projection of like or artificially generated images; videography; live broadcast including that via radio carrier waves, closed circuit systems, or the Internet; surveillance; minimally invasive omnidirectional observation and imaging of difficult to access subjects, as applicable to dry or immersion bore scopes; the enabling and enhancement of assembly and inspection techniques; omnidirectional expansion or reception of lasers and other light sources for applications such as illumination, optical communication, or optical motion sensing; robotic vision systems; vision and subject recognition for autonomous and other flight control or simulation systems, including virtual reality systems; and for viewing, observing, measuring, imaging, recording, broadcasting, projecting, or simulating defined or diffuse subjects of large angular subtense, such as weather related events or the boundary of the lunar umbra as projected on the earth's atmosphere during a total solar eclipse. The omniramic optical system may be used in any orientation; however, it is typically used in a vertical orientation for panoramic applications.

The omniramic imaging system typically consists of a strongly curved convex primary reflecting surface having a prolate aspheric figure, said primary reflecting surface having sufficient curvature to image a field of view greater than 180 degrees, thereby providing means to image a great circle surrounding it; a secondary reflector surface, an imaging lens system, and mechanical mounting components which typically include an axial strut to axially support instrumentation or a secondary reflector in front of the primary reflector without obstructing subject matter which is perpendicular to the optical axis, though other support means such as a thin off-axis support vane producing minimal obstruction are applicable.

DESCRIPTION OF THE PRIOR ART:

Assembly of a plurality of discrete images to form a fixed or moving panoramic image is common in the prior art. A less common image assembly method relates to coverage the entire sphere around a camera by means of assembling opposing images taken with a fisheye lens having a field of view greater than or equal to 180 degrees. One such type of prior art relates to the simultaneous use of two hyperhemispherical fisheye lenses to take still images, as embodied in Dan Slater's Spherecam. Another relates to the alternate use of a single hemispherical fisheye lens to capture images in opposing directions, said fisheye lens being used in combination with an indexing bracket having means to index the 180 degree zone of the typically distorted entrance pupil of said fisheye lens in the same position when recording each of the opposing still images, as embodied in the IPIX system and related U.S. patents 5,384,588 and 5,631,778. Motion picture systems include the Circle Vision 360 theater at Disneyland and other systems having various degrees of coverage such as planetariums equipped with Omnimax projectors.

The use of a single refractive optical system in hyperhemispherical and panoramic imaging is common in the prior art. Systems utilizing refractive means include rotating panoramic cameras, fisheye lenses, and J.M. Slater's whole sky lens, as shown on page 582 of the October 1932 issue of American Photographer.

Reflectors are also widely used in hyperhemispherical wide angle panoramic imaging and projection. Systems of this type are shown in U.S. Patent Nos. 5,631,778 (Panoramic fish-eye imaging system), 5,115,266 (Optical system for recording or projecting a panoramic image), 4,395,093 (Lens system for panoramic imagery), 4,012,126 (Optical system for 360 degree image transfer), 3,846,809 (Reflectors and mounts for panoramic projection), 3,822,936 (Optical system for panoramic projection), and D312,263 (Wide angle reflector attachment for a camera or similar article), and as embodied in disclosures of the Omnicamera at the www.cs.columbia.edu web site; the Be Here panoramic lens prototype at the www.behere.com web site; and the Versacorp Omnirama T11 axial strut omniramic reflector (an embodiment of the present invention authorized by the applicant) at the www.versacorp.com web site.

Optical reflector configurations include a simple reflector disposed directly in front of a camera lens, as embodied in the Spiratone Birds Eye Attachment (shown in the Spiratone 1976 Bicentennial Sale catalog, page 28), to a Cassegrain system having integral imaging optics as shown in U.S. Patent Nos. 4,012,126 (Optical system for 360 degree image transfer) and Figures 6 through 12 of U.S. Patent No. D312,263 (the applicant's patent for a Wide angle reflector attachment for a camera or similar article).

Support means for a camera or reflective optical element include a tripod; a transparent cylinder of the type embodied in the Spiratone Birds Eye Attachment; a transparent hollow semi-sphere of the type shown in U.S. Patent Nos. 4,395,093 (Lens system for panoramic imagery) and 4,012,126 (Optical system for 360 degree image transfer); an axial strut of the

type shown in U.S. Patent Nos. 5,115,266 (Optical system for recording or projecting a panoramic image), 3,846,809 (Reflectors and mounts for panoramic projection), and D312,263 (Wide angle reflector attachment for a camera or similar article), or pages 74 to 80 of the 1988 Riverside Telescope Makers Conference proceedings; and a solid optical substrate of the type shown in the applicant's co-pending provisional applications, serial Nos. 60/043,701 and 60/055,876.

Reflective surfaces consist of external reflectors, as shown in U.S. Patent Nos. xxxxxxxx ; an internal optical surface having a reflective coating xxxxxxxx ; internal surfaces which utilize total internal reflection, of the type shown in U.S. Patent No. 4,566,763 (Panoramic imaging block for three-dimensional space), as shown in the JPL Radial Profilometry paper; and as embodied in the Peri-Apollar lens.

Reflector substrates include spun, machined, polished and conventionally plated metal surfaces as embodied in the larger reflector invention on page 186 of the August 1986 issue of Sky and Telescope, page 68 of the April 1987 issue of Astronomy, and as shown and described on pages 74 through 80 of the proceedings of the 1988 Riverside Telescope Makers Conference; electrolytically replicated metal surfaces, including those having an outer coating of Rhodium, as embodied in Melles Griot concave light multipliers on page 12-17 of the Optics Guide 5 catalog; glass having a reflective coating, as embodied in the Spiratone Birds Eye attachment; transparent refractive material having a reflective coating, as shown in U.S. Patent No. D312,263 (Wide angle reflector attachment for a camera or similar article); plastic having a reflective coating, as embodied in the smaller reflector invention on page 186 of the August 1986 issue of Sky and Telescope.

Some of the prior art consists of or incorporates refracting optics to eliminate field curvature. Some of these optics also reduce aberrations. Used alone, reflector systems can produce aberrations, with the most severe aberrations typically being off-axis.

Many of these reflector principles can be more elegantly addressed through examination of prior art in the more mature field of Cassegrain telescopes and telephoto cadadioptric camera lenses: In these systems, the relative figures of the primary and secondary mirrors can be manipulated in order to reduce imaged on-axis aberrations to a size smaller than the Airy disk. In addition, the figures of the primary and secondary mirrors can be manipulated to affect off-axis aberrations in a way which reduces the severity of aberrations or results in an aberration which is relatively practical to correct by means of relatively small auxiliary refracting optics which are located relatively near the focal plane. Cassegrain telescope systems include the Ritchey-Chrétien, a telescope having a concave hyperboloidal primary mirror and a convex hyperboloidal secondary mirror. This combination results in off-axis astigmatism, an aberration relatively difficult to correct with refracting optics if they are located in close proximity to the focal plane. Another Cassegrain system is the Classical Cassegrain, a telescope having a concave paraboloidal primary mirror and a convex hyperboloidal secondary mirror. Coma is the predominant aberration with this system, and coma is relatively easy to correct or reduce with refracting optics, even if they are located relatively near the focal plane. Accordingly, refractive coma correctors are commonly available for commercial Cassegrain telescopes. Simpler published coma corrector designs include those by Brixner, Jones, and Jones-Bird. These simpler systems are designed for Newtonian telescopes and they correct coma at the expense of introducing other aberrations; however, these are advantageous when their use will reduce the overall size of the combined imaged aberrations to an acceptable level. A more effective corrector for Classical Cassegrain and Schmidt-Cassegrain telescopes is a four element system offered by Celestron, and more recently, by Meade Instruments.

This optical system has substantial positive optical power which results in a smaller (faster) numerical focal ratio at the focal plane than that of the telescope alone. More sophisticated corrector lenses are utilized in compact Catadioptric telephoto camera lenses. These include the Nikon 500 mm telephoto mirror lens and the Vivitar 800 mm Solid Catadioptric telephoto lens for a 35 mm camera. In telephoto lenses, corrective lenses are occasionally used in combination with reflective optics in which imaging aberrations roughly equal and opposite of residual aberrations of said corrective lenses have been deliberately introduced.

In the case of a convex wide angle reflector, a virtual image typically exists on an imaginary curved surface typically being disposed behind said convex reflector. When a real image is produced by means of imaging the virtual image with a conventional lens system, aberrations present in said virtual image are typically repeated to the real image. In addition, the curvature of the virtual image results in curvature of the surface of best focus for the real image. Therefore, a wide angle reflector system must incorporate or otherwise utilize means for correcting field curvature and reducing or correcting aberrations in the virtual image if the real image is to be of high overall resolution and still facilitate a flat focal surface. Imaging lens systems having means to correct field curvature and at least some aberrations exist in the prior art. An imaging lens system of this type is shown in U.S. patent Nos. 4,484,801 (Panoramic lens with elements to correct Petzval curvature), 4,395,093 (Lens system for panoramic imagery), 4,012,126 (Optical system for 360 degree image transfer). Corrective optics not previously associated with wide angle imaging include a curved field lens system of the type used to sharply image the curved surface of a CRT, as embodied in older oscilloscope cameras.

Primary reflector figures include spherical and aspheric - Sky and Telescope

Secondary reflector figures include flat, concave...

All references cited in the applicant's patent D312,263 can be considered "Prior Art Cited By Applicant" in the present application.

BRIEF DESCRIPTION OF THE PRESENT INVENTION:

The present invention relates to an optical wide angle optical imaging system which is typically made up of both refracting and and reflecting optics, and which is associated with a camera, projector, medical instrument, surveillance system, robotic system, flight control system, or similar article. More particularly, the preferred embodiment of the present invention is a nearly omnidirectional (omniramic) optical system typically consisting of a convex primary reflector having a prolate aspheric figure and a hole or transparent area in its center, a secondary reflector typically having a convex figure, an imaging lens system optically disposed between and in optical communication with the reflector and the focal plane, light baffles, aperture adjustment means, and mechanical mounting components. Mounting components for the preferred embodiment typically include an axial strut to axially support instrumentation, a camera, or a secondary reflector; with the end of said axial strut closest to the foal plane being supported by an optically clear lens or window. Other embodiments may support instrumentation, a camera, or a secondary reflector by means of an off-axis vane having a thin profile as seen from the optical axis, said vane also providing means for routing wires or other fixtures to and from the end farthest from the primary reflector.

Various features of the present invention may be interchanged between all embodiments, depending on the application. The degrees of freedom resorted to in different embodiments of the invention include the materials and manufacturing techniques used to make the invention, the size of the invention, the eccentricity and degree of curvature of the primary reflector figure, the radial offset (or torroidal curvature, where present) of the primary reflector figure, the size and figure of the window (or nonreflective area in the center of the primary reflector surface, where a transparent substrate is used), whether or not said window or transparent area supports an axial strut, whether or not said window or transparent area is flat or curved on

order to have optical power, the figure of the secondary reflector, the existence, size and figure front refractive surfaces for the primary or secondary reflectors, the size and type of primary baffle used, the size and type of secondary baffle used, whether or not some or all of the imaging optics are an integral part of a clear primary reflector substrate (if used), the figure of the imaging lens(es), whether or not aperture adjustment means are provided, the means used for aperture adjustment, the position of the focal plane relative to the invention, and any combination of these degrees of freedom.

SUMMARY OF THE PRESENT INVENTION

The applicant has shown in his prior U.S. Patent No. D312,263 means for imaging a field of view which is omniramic, or nearly omnidirectional. The results shown in said prior patent were achieved by an optical system consisting of two external reflectors and a small imaging lens system. The incoming light is reflected by a strongly curved convex reflector having a prolate aspheric figure to a smaller flat secondary mirror which is centered on the optical axis directly in front of said primary reflector, being supported by an axial strut. From the secondary mirror, light is reflected through a transparent area in the center of the primary reflector substrate, where it is refracted by an imaging lens to produce a real image of the virtual image formed by the primary reflector at the focal plane. The end of the axial strut closest to the camera is supported by the transparent area in the center of the primary reflector.

The maximum theoretical field of view includes the entire sphere around the primary reflector with the exception of a front conical area that is within no less than 18 degrees of the optical axis and a rear conical area that is within no less than 20 degrees of the optical axis. When pointed upward, the coverage of the optical system includes the entire horizon and all of the area extending from less than or equal to 72 degrees above the horizon to less than or equal to 70 degrees below. If it is allowed, the applicant claims the benefit of all art which is supported by but not claimed in U.S. patent D312,263. ------attributes--------in prior?

In the field of the present invention, it is important to distinguish between two definitions which are often applied to the concept of an "omnidirectional" field of view or a 360 degree angle of view:

The most accurate definition relates to the actual angle of view of an optical system, where the specified angle of view is determined by the true angular coverage of the system relative to its optical axis; meaning that if an optical system is truly has 360 degree omnidirectional coverage, it must cover the entire sphere around itself. According to this

definition, the present invention is not capable of imaging the entire sphere in a contiguous image owing to a conical exclusion zone behind its primary reflector, and in some embodiments, a second conical exclusion zone in front of the primary reflector.

The more inaccurate definition of omnidirectional relates to the fact that a great circle (such as the horizon) can be imaged by an optical system which has a field of view greater than 180 degrees. Such a system is not truly omnidirectional. This definition is often used in promotional material, such as that for the Peri-Apollar, use to incorrectly specify that an optic covers 360 degrees, when in fact it may only cover 240 degrees. According to this definition, all embodiments of the present invention (including those with a central obscuration) would cover 360 degrees. In order to eliminate confusion, the term "Omniramic" (a probably originated by the applicant) shall be used to describe this type of coverage.

The applicant has shown in U.S. provisional application serial number 60/043,701 an improved means for imaging a field of view which is omniramic, or nearly omnidirectional. The present invention is applicable to both original imaging of a subject and for projection of photographic or artificially generated (including computer generated) images. The invention is applicable to the reception or transmission of light or other radio energy for purposes other than imaging. In this description, the invention will typically be described in terms of an imaging system such as that used with or incorporated into a film or electronic camera. Obviously, directions traveled by light or other energy will be reversed where the invention is used for projection, and, in the case of applications other than imaging, the subject energy or material will propagate according to the same laws of physics regardless of the direction and whether or not imaging applications are involved.

The invention will be more clearly understood from consideration of the following description in connection with accompanying drawings that form a part of this specification.

It is the object of the present invention to...

The present invention is an improved means for imaging or projecting a field of view which is omniramic, or nearly omnidirectional. The present invention achieves the result of an omniramic image projection similar to a polar map projection __ in substantially the same way as the invention shown in my prior design patent D312,263; however, the present invention is an improvement of the invention in said patent D312,263. More particularly, the present invention utilizes more sophisticated optics and components to facilitate: improved performance, improved durability, a shorter distance between reflectors, a shorter mechanical support structure, a smaller and lighter secondary reflector assembly, greater rigidity, smaller exclusion zones, reduction or elimination of a front exclusion zone, elimination of a rear exclusion zone through the use of auxiliary optics, redundant imaging, elimination of field curvature, reduction of aberrations, accurate indication of image edges, improved reduction of stray light, occultation of an excessively bright light source (such as the sun) to reduce or eliminate flare, improved protection of optical surfaces, improved aperture adjustment means, improved ease of handling, improved ease of use, compatibility with a wider array of storage and transportation means, superior compactness vs. performance, compatibility with a wider array of fabrication modes, lower production cost, superior performance in projection applications, compatibility with a wider array of cameras and other instruments, improved usefulness in a wider range of environments, and modular construction.

The minimum possible excluded cone behind the primary reflector has a diameter of about 10 degrees, but a diameter of at least 40 degrees is more practical to implement. This area is covered by means of an auxiliary off-axis optical system __ facing in the opposite direction of the primary reflector, said auxiliary optical system having relay optics __ and reflective means __ to produce a final image at the focal plane, said image being on a common focal plane __ with the annular image, disposed in the center of or immediately beside said annular image.

Additional fixed and steerable auxiliary optics may be utilized for redundant imaging of the central area and selected off-axis subject areas.

A basic embodiment of the present invention __ utilizes a prolate aspheric reflector __. This results in exclusion of a conical area __ in front of the primary reflector __, which is caused by obscuration by a secondary reflector __, a camera __, or a transparent zone in the primary reflector.

The front conical exclusion angle __ is reduced by means of a primary reflector having a figure which is enlarged in a direction perpendicular to the optical axis __ while still retaining rotational symmetry. This causes the part of the primary reflector immediately ...

A front exclusion zone is completely eliminated by means of a torroidal primary reflector __ and a small convex secondary reflector __ having a diameter less than the diameter of the apex of the torroid of said primary reflector. Elimination of the front conical exclusion zone is accomplished by redundantly imaging the part of the subject __ a finite distance directly in front of the primary reflector __ at the radial zone of the annular image circle __ which is closest to the center by means of a primary reflector having a torroidal figure __ combined with a secondary reflector assembly __ having a diameter smaller than the torroidal apex __ of said primary reflector. The remainder of the subject __ is progressively imaged toward the outer edge of the annular image __. Optical surfaces used to accomplish this consist of a strongly curved prolate aspheric primary reflector __, a moderately convex secondary mirror __, and rear imaging optics __. The secondary mirror is in optical communication __ with both the primary reflector and the imaging lens system which is located behind a central transparent zone __ in the primary reflector...

If desired, the transparent central zone in the center of the primary reflector surface can have a figure which will act as a refracting lens. Where an axial strut __ is used, the surface of a transparent optical window suporting it __ can be located at the same or at different

longitudinal positions than the surrounding zone of the primary reflector by means of a cell which is recessed behind said primary relfector or extends in front of it.

The rear imaging lens __ is used to form a real image of the subject by imaging the virtual image __ which is typically beyond the surface of the secondary mirror...

--- Please see accompanying document for more on the optics -----

Manipulation of the annular image is necessary for sime applications. Annular images produced with the present optical invention may be viewed directly; however, said images may seem distorted to most observers. Therefore, it is typically desirable to convert the annular image to a more conventional format. The applicant has shown in his paper of March 9, 1997 entitled "Converting Panoramas to Circular Images and Vice Versa - Without a Computer!" means to convert a circular image to a rectangular format or vice versa. These techniques were first implemented in a photographic darkroom, and utilize a tilted concave easel which receives unexposed photographic paper or film, said tilted easel being curved according to a conical surface and providing active linear dodging and color filtration means to compensate for reciprocity failure in the photographic paper or film caused by the variable exposure time which is required due to the pronounced tilt of said easel. Combined with an enlarger having a wide angle lens and a tiltable lens standard, the concave easel facilitates incremental conversion of an annular image to a rectangular format, and vice versa.

The applicant implemented the described techniques in a photographic darkroom during October, 1976 to convert a series of photographs covering the entire 360 degree horizon into a flat and continuous annular image. Projection onto the correctly shaped and tilted concave conical surface easel converts each rectangular image into a shape resembling a truncated pie slice and curves the horizon and other image elements of to the degree appropriate for the annular which results from assembling the individual prints. If the top end of the original image is toward the top of the easel, the sky will be toward the central part of the resulting annular

image. The entire process is compatible with conversion of an annular image into a rectangular one by incrementally projecting the the part of the annular image toward the center onto the bottom end of the tilted concave easel. The applicant further described that these techniques are applicable to like and similar geometric conversions of an image by exposing paper or film on a moving flat or curved easel through a slit which is in optical communication with a lens and a moving carrier for the original image. Additionally, the applicant described that these techniques are also applicable to other modes of image manipulation, including digital image processing. Digital image processing offers more degrees of freedom and greater extremes of image manipulation than a single stage darkroom based technique can provide, and need not be relegated strictly to an incremental or linear conversion process.

Digital image manipulation based on the applicant's prior darkroom techniques provide means for the geometric conversion of an annular image such as that produced by the present optical invention into a distorted or undistorted rectangular format and vice versa, said manipulation means also providing for the extraction of distorted or undistorted parts of the image. As in the darkroom process, conversion is based on progressive circumferential expansion of the annular image data from the outer circumference toward the center, expanding the inward part of the image until its circumference matches that of the outer circumference, thereby resulting in a rectangular image. Expansion can be accomplished by adding pixels which repeat the data of those immediately surrounding it, and said expansion can be accompanied or replaced by progressive circumferential compression of the outer zones of the image.

Assuming that the original annular image is recorded with the primary reflector facing directly upward, the great circle of the horizon will be imaged as a circle at a given radial zone of said annular image. Using the described process, the image may be converted in whole or in part to a rectangular format or other desired forms. Where the resulting rectangular image is oriented with its long dimension extending horizontally, the horizontal image scale is constant and the

field of view can even exceed 360 degrees when the image is made long enough to facilitate redundant horizontal coverage. Where the original annular image has a constant radial image scale, the resulting rectangular image will have a constant vertical image scale, though the vertical image linearity can be manipulated by processes analogous to tilting the easel, translating the easel, warping the easel, and utilizing an enlarging lens having projection characteristics other than rectilinear. The proportions of the subject matter in the center of the resulting rectangular image are determined by the selected radial zone of unity expansion in the annular image. Where it is desirable for the horizontal image scale to match the vertical image scale, the zone of unity expansion is selected the radial zone of the annular image having a diameter of the relative length of the horizontal image divided by pi. Digital image processing based on this principle is also capable of converting a contiguous circular image having true omnidirectional coverage (as opposed to an annular one) into a rectangular format, since this is simply a matter of enlarging the inner zones of the image to a progressively greater degree, with the central pixel data being repeated across the entire top pixel row of the resulting rectangular image.

Further appropriate modification of the rectangular image is accomplished by implementing techniques analogous to projecting an original cylindrical or spherical image surface onto a flat surface with a point light source. The cylindrical to planar conversion results in a rectangular image having increasing image scale above and below a specified horizontal central line (typically the horizon), said expansion being equal to the reciprocal of the cosine of the angle above and below the center, resulting in an image having the same geometrical characteristics an image produced with a rotating panoramic camera having a rectilinear lens. The spherical to planar conversion results in a rectangular image having increasing image scale in all directions from a specified center, said expansion being equal to the reciprocal of the cosine of the angle from said specified point, resulting in an image of limited coverage having the same characteristics as an image produced by a rectilinear lens. (For reference, a rectilinear lens has

the same image projection characteristics as a pinhole camera having a flat focal plane.) Any subset or combination of the above conversion techniques can be used to influence the image in whole or in part. Additionally, software applications can facilitate the simultaneous implementation of these processes. In the case of intensive image manipulation such as may be required for full motion digital display, active pixel reassignment may be implemented.

The applicant has described in his paper of 14 February, 1997 entitled "Techniques for Wide Angle Panoramic Photography of the Lunar Umbra at Total Solar Eclipses" concepts and methods for active pixel assignment which are primarily used to correct for radial expansion characteristics of a rectilinear wide angle lens when it is used with an incrementally or continuously rotating panoramic camera having a predominantly linear sensor array of substantial width. These methods are not claimed in and of themselves herein, but they are applicable to enhancing the image manipulation aspects of the present invention. N. A.

This disclosure is considered as illustrative of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction, operation, and appearance as shown and described, and accordingly all suitable modifications and equivalents may be resorted to without thereby departing from the basic principles of the invention. It will be further understood that the invention is susceptible of embodiment in many various forms, some of which are illustrated in the accompanying drawings, and that structural details and modes of fabrication herein set forth may be varied and interchanged to suit particular purposes and still remain within my inventive concept. Digital image processing according to any subset or combination of the above conversion techniques can be used to influence the image in whole or in part. Additionally, software applications can facilitate the simultaneous implementation of these processes. In the case of intensive image manipulation such as may be required for full motion digital display, active pixel reassignment may be implemented.

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(Not in U.S. Application)

-- Claim conversion technique for annular and circular images
-- claim Fresnel lens (should be OmniLens) LD solid micro.
-- claim use of Barlow to flatten field - oscilloscope lens
-- claim lighting, wire routing at optical center
-- claim field flattener, astigmatism, sec. curv to intro coma

1 easel 3 med format 5 side strut 12 more proj, torroid, suites, off center reflect
13, remote, torroid 14 torroid, fast f/ratio, field flat, hole in sec, hollow strut to OC for wiring
15 proj charact, level, sphere, mangin sec, sensor built in,
16 theaters, 3d, separated off center refl, scalloped, simulator
17 3d axial, opposing axial

~~as supported by U.S. provisional application serial number 60/055,876, filed August 15, 1997;~~
While the invention may be used in many orientations, a primary use is for simultaneous imaging and projection of an entire 360 panorama which includes a great circle surrounding the invention, said great circle being perpendicular to the optical axis. This is typically accomplished by using the invention in a vertical orientation, in which case, a great circle perpendicular to the optical axis corresponds to a flat horizon. For clarity, all descriptions of the present invention apply to an vertical orientation with the surface of its primary reflector facing up.

Improvements of the present invention over the applicant's prior embodiments relate primarily to miniaturization, increased off-axis resolution, increased vertical coverage, improved compatibility with low cost modes of production, improved durability, and compatibility with a wider array of cameras, projecors, and other instrumentation.

The primary differences between embodiments having a large or a small conical exclusion zone in front of the primary reflector is the figure of the primary reflector, the size of any central hole in said primary reflector, and the size and proximity of a central obstruction.of a with the reflector on embodiments with a reduced exclusion zone having a radially offset (i.e. outwardly offset) figure. Embodiments having a small conical exclusion zone utilize a radially

PCT 20
(not in U.S. Application)

enlarged primary reflector. For a given moderately central zone, radial enlargement results in an angle of reflection which is closer to perpendicular with the optical surface, resulting in coverage closer to the center of

The primary difference between embodiments with and without annularly imaged central coverage is the figure of the primary reflector and the relative size of a central obstruction such as a secondary reflector and its baffle or any other article such as a camera. Embodiments having central coverage utilize a torroidal primary reflector. The size of the central obstruction influences the percentage of the image circle which will be obstructed by it and the degree of radial enlargement which must be incorporated into the torroidal reflector in order to image the central subject (or projection area) which is beyond said central obstruction. Where the subject is at infinity, the zone of the primary reflector which is used in imaging the central subject must have a diameter at least as large as the central obstruction. Where the subject is at a finite distance from the optical system, the zone of the primary reflector imaging it must be larger than the diameter of the central obstruction. Therefore, in the preferred embodiment of the invention having a torroidal primary reflector, the zone of said primary reflector imaging the central subject is larger than the central obstruction.!!

The primary differences between embodiments for different applications include overall size; relative sizes of different optical surfaces; materials used; the presence or configuration of moisture and contaminant seals; optimization of the optical figure for immersion, where applicable; and the relative size and longitudinal position of the focal surface.

What is claimed is:

1. An optical system comprising:

* a convex primary reflector having radial symmetry,
    * said primary reflector being in optical communication with a great circle surrounding it, the plane of said great circle being perpendicular to the optical axis of said primary reflector,
    * said primary reflector having sufficient curvature to be in optical communication with a substantial area in front of and behind the plane of said great circle,
    * said primary reflector having an optically transparent central zone,
* a secondary reflector having radial symmetry,
    * said secondary reflector being coaxially disposed in front of said primary reflector,
    * said secondary reflector having its reflective surface facing the reflective surface of said primary reflector,
    * said secondary reflector being in optical communication with said great circle surrounding said primary reflector and said area in front and behind the plane of said great circle by means of reflection from said primary reflector,
* whereby said optical system produces a virtual image of said great circle and said area above and below its plane, said virtual image being annular,
    * said virtual image being visible from a vantage point behind said optically transparent central zone of said primary reflector due to said vantage point being in optical communication with said great circle and said area in front and behind the plane of said great circle by means of

reflection from said secondary reflector and said primary reflector,

* means for mounting said secondary reflector and said primary reflector,
    * said means providing a protective darkened shield around the perimeter of said secondary reflector, said shield also acting as a light baffle,
    * said means for mounting providing stable support and alignment of said primary reflector and said secondary reflector without causing deformation thereof,
    * said means for mounting providing for attachment of said optical system to an article having a focal surface,
    * said mounting means not relying on the structure of said primary reflector surface substrate to support said article,
    * said mounting means facilitating use of said optical system in any orientation,
    * said optical system typically being associated with a refracting lens system, said refracting lens system being disposed coaxial to said optical system, both being associated with the formation of a real image of said virtual image at said focal surface,
* whereby said optical system combined with said article facilitate the geometric conversion of said great circle and said area in front and behind the plane of said great circle into a real annular image at the focal surface of said article and vice versa,

2. apparatus according to claim 1 in which said primary reflector comprises a surface of revolution, said surface of revolution having a prolate aspheric figure,

3. apparatus according to claim 1 in which said primary reflector comprises a surface of revolution, said surface of revolution having a prolate aspheric figure, the virtual image produced

by said primary reflector having a constant radial image scale when said primary reflector is viewed from an an axial vantage point having an equivalent optical distance of one to four times the diameter of said primary reflector from the apex of said primary reflector, (Remarks: if claim 1 is too broad, this claim may incorporated into it.)

4. apparatus according to claim 1 in which said primary reflector comprises a surface of revolution, said surface of revolution being radially compressed inward toward the optical axis, whereby the surface said primary reflector is farther from being perpendicular with the optical axis at a zone which immediately surrounds said transparent central zone, whereby said vantage point behind said transparent central zone of said primary reflector is in optical communication with a smaller angular area in front of said great circle, thereby increasing the size of the central angular exclusion zone in front of said primary reflector while increasing the radial proportions of the area immediately surrounding the plane of said great circle, thereby resulting in a larger radial image scale for said area covered on a given image format, owing to the virtual absence of an imaged central obscuration area,

5. apparatus according to claim 1 in which said primary reflector comprises a surface of revolution, said surface of revolution having a prolate aspheric figure, said prolate aspheric figure also being radially enlarged outward from the optical axis, whereby the surface said primary reflector is closer to perpendicular with the optical axis at a zone which immediately surrounds said transparent central zone, whereby said vantage point behind said transparent central zone of said primary reflector is in optical communication with a greater angular area in front of said great circle, thereby reducing the size of the central angular exclusion zone in front of said primary reflector, radially enlarged primary reflector also permitting said transparent central zone to be enlarged without affecting the field of view, said enlarged transparent zone

permitting the use of large aperture refracting optics such as those associated with a camera or a projector, said secondary reflector with its associated mounting and shielding being relatively small in order to minimize obscuration of subject matter in front of said primary reflector, whereby said combination of attributes typically result in a conical obscuration having a diameter of less than 60 degrees,

6. apparatus according to claim 1 in which said primary reflector comprises a surface of revolution, said surface of revolution having a prolate aspheric figure, said prolate aspheric figure also being torroidal as a result of being radially enlarged outward from the optical axis, whereby the surface of said primary reflector curves backward in the zone immediately surrounding said transparent central zone, whereby the radial zone of said primary reflector by which the inner zone of said secondary reflector is in optical communication with an axial point disposed at a finite distance in front of said optical system by means of reflection from said zone of said primary reflector which has a larger diameter than said secondary reflector with its associated mounting and shielding, whereby said vantage point behind said transparent central zone of said primary reflector is in optical communication with the entire area in front of said great circle up to said axial point disposed at a finite distance in front of said primary reflector, thereby eliminating the central angular exclusion zone in front of said primary reflector, the only excluded area being confined to a narrow conical area extending from the perimeter of said secondary reflector with its associated mounting and shielding to said axial point disposed a finite distance in front of said primary reflector, said torroidal primary reflector also permitting said transparent central zone to be enlarged without affecting the field of view, said enlarged transparent zone permitting the use of large aperture refracting optics such as those associated with a camera or projector,

7. apparatus according to claim 1 in which said primary reflector has a scalloped surface resulting in more than three identical convex lobes disposed evenly around its circumference, each lobe having more than twice the included angle as the angular circumference of the reflector body it occupies; for example, as seen from the front, each lobe of an eight lobe reflector would occupy 45 degrees of the circumference; therefore, each of said lobes would have more than 90 degrees of curvature as seen from the front; said primary reflector providing a sectored virtual image, said image having the same number of sectors as said primary reflector has lobes, each of said sectors covering a circumferential angle of view of more than twice the circumferential angle occupied by each sector, whereby said virtual image covers each point in said great circle and said area in front and behind the plane of said great circle at least twice, thereby providing fully redundant coverage thereof; said twice imaged points having circumferentially separated vantage points and being circumferentially separated in said virtual image, said redundant coverage providing three dimensional information for the entire area of coverage; said optical system also being applicable to the projection of sectored images whereby said redundant images overlap and include three dimensional information; the concepts, principles,and geometry of said optical system are also being applicable for the basis of image processing techniques, algorithms, and software which are associated with viewing, analyzing, and otherwise utilizing images produced and reproduced by said optical system, as supported by U.S. provisional application serial number 60/055,876, filed August 15, 1997;

8. apparatus according to claim 1 in which said primary reflector is made of optically transparent material, said optically transparent central zone of said primary reflector consisting of a hole in its reflective coating, the surface of said substrate being radially symmetrical within said hole in reflective coating,

9. apparatus according to claim 8 in which said primary reflector substrate is plastic, said substrate also extending behind the perimeter of the reflecting surface and providing a protective rim behind said reflecting surface and providing a grip surface to facilitate handling without marring said reflective surface,

10. apparatus according to claim 1 in which said optically transparent central zone of said primary reflector consists of a hole through said primary reflector substrate,

11. apparatus according to claim 10 in which said primary reflector consists of a metal substrate having an electrolytically replicated figure,

12. apparatus according to claim 6 in which a round baffle may be attached to said secondary reflector with its associated mounting and shielding, said round baffle being having longitudinal positioning means, whereby the shadow of said round baffle changes the distance of said axial point disposed a finite distance in front of said primary reflector, thereby providing means for said axial point to coincide with the distance of a front projection surface, thereby resulting in a seamless projection across the central part of a projection surface having a finite distance from said optical system, said apparatus being associated with the projection of images which completely surround the viewing participant, as supported by U.S. provisional application serial number 60/055,876, filed August 15, 1997;

13. apparatus according to claim 6 in which said secondary reflector is a convex surface of revolution and said secondary reflector with its associated mounting and shielding having a diameter less than forty percent of the diameter of said primary reflector,

14. apparatus according to claim 1 in which said secondary reflector is a convex surface of revolution, said convex surface allowing said convex secondary reflector and its associated shield to be smaller and lighter a flat reflector with its associated shielding, whereby mounting said secondary reflector is simplified due to its lighter weight and smaller surface area, said smaller surface area resulting in less wind loading, said smaller secondary also facilitating a smaller

central obscuration angle, (Remarks: if claim 1 is too broad, this claim may incorporated into it.)

15. apparatus according to claim 1 in which said secondary reflector is a convex surface of revolution having a figure which is radially compressed inward toward from the optical axis in order to facilitate an unchanged field of view while not imaging said central transparent area in center of said primary reflector surface, thereby allowing the radial image scale of the covered area to be increased owing to the virtual absence of imaged central obscuration area, said convex surface also providing for the correction of off-axis aberrations,

16. apparatus according to claim 1 in which the figure of said secondary reflector surface is an aspheric surface of revolution and provides means for the substantial correction of off-axis astigmatism which results from off-axis reflections off of said primary reflector, said aparatus further comprising refracting optics which are coaxial with said primary reflector and in longitudinal proximity to said transparent central zone of said primary reflector, said refracting optics correcting for residual aberrations from said primary reflector and said secondary reflector, (not supported in provisional applications)

17. apparatus according to claim 1 in which the substrate of said secondary reflector is transparent, having the reflective surface on the side opposite said primary reflector, the side of said substrate toward said primary reflector also having a surface of revolution and acting as a refracting surface, said refracting surface not being concentric with said secondary reflector surface, said refracting surface providing means for the substantial correction of off-axis astigmatism, said optical system further comprising refracting optics which are coaxial with said primary reflector and in longitudinal proximity to said transparent central zone of said primary reflector, said refracting optics correcting for residual aberrations from said primary reflector and said secondary reflector, (not fully supported in provisional applications)

18. apparatus according to claim 1 in which the secondary reflector is convex, further comprising an annular reflector which is coaxial with said secondary reflector, said annular reflector having sufficient curvature to cover the same area in front and behind said great circle as said primary reflector, said annular reflector having a longitudinal position which places its virtual image in close longitudinal proximity to that of said virtual image from said primary reflector as reflected in said secondary reflector, said virtual image from said annular reflector being visible from a vantage point behind said optically transparent central zone of said primary reflector due to said vantage point being in optical communication with said great circle and said area in front and behind the plane of said great circle by means of reflection from said annular reflector, said annular reflector providing redundant coverage, said redundant coverage providing three dimensional information for the entire area of coverage, as supported by U.S. provisional application serial number 60/055,876, filed August 15, 1997;

19. apparatus according to claim 7 in which the secondary reflector is convex, further comprising an annular reflector which is coaxial with said secondary reflector, said annular having sufficient curvature to cover the same area in front and behind said great circle as said primary reflector, said annular reflector having a longitudinal position which places its virtual image in close longitudinal proximity to that of said virtual image from said primary reflector, as reflected in said secondary reflector, said virtual image from said annular reflector being visible from a vantage point behind said optically transparent central zone of said primary reflector due to said vantage point being in optical communication with said great circle and said area in front and behind the plane of said great circle by means of reflection from said annular reflector, said annular reflector providing redundant coverage, said redundant coverage providing three dimensional information in all axes of the entire area of coverage, (not supported in provisional applications)

20. apparatus according to claim 1, further comprising at least one refracting optic, said

refracting optics having a negative optical power, said refracting optics being coaxial with said primary reflector and in longitudinal proximity to said transparent central zone of said primary reflector, whereby said refracting optics provide for said vantage point behind said optically transparent central zone of said primary reflector to be moved to a substantial axial distance behind said transparent central zone, thereby allowing unobstructed optical communication between said moved vantage point and the entirety of said secondary reflector while allowing said transparent central zone of said primary reflector to have a relatively small diameter,

21. apparatus according to claim 1 in which said mounting means for connecting said primary and said secondary reflector consist of a single darkened strut, said strut being coaxial with both reflectors, said strut having a diameter which is increased toward the end closest to said secondary reflector, said axial strut being coaxially supported in front of said vantage point by means of an optically transparent substrate, whereby the combination of said strut and transparent substrate provide stable support and alignment means for said secondary reflector, and thin enough so as not to obstruct the subject area (Remarks: if claim 1 is too broad, this claim may part of it.)

22. apparatus according to claim 21 in which said transparent substrate is in a cell, said cell being attached to mounting structures for said primary reflector and said article, said cell protruding in front of the apex of said primary reflector, said cell being removable, whereby said cell, said axial strut, and said secondary reflector assembly may be removed from the overall optical system as a unit, said axial strut also having adjustment means for its length, said darkened shield associated with said secondary reflector having provision to accept a variety of additional shields; said shields being interchangeable, said shields being flat cylindrical, and conical; the perimeter of said conical and cylindrical shields extending a short distance toward said primary reflector, as supported by U.S. provisional application serial number 60/055,876, filed August 15, 1997;

23. apparatus according to claim 1 in which said secondary reflector shield has a conical

shape of moderate taper, said conical shape having the largest diameter at the end toward said the primary reflector, said shield extending a moderate distance from around the perimeter of said secondary reflector toward a zone near the perimeter of said primary reflector,

24. apparatus according to claim 1 in which said mounting means for connecting said primary and said secondary reflector consist of a single vane, said vane being off-axis and having a cross section of less than three degrees when viewed from the optical axis, said vane also having means to route electrical cable and similar articles, said vane further having means to accept an attachment providing means for occulting bright light sources which would otherwise cause flare; whereby said vane provides stable support and alignment means for said secondary reflector, (supported by remarks in both provisional applications)

25. apparatus according to claim 1 in which said mounting means for connecting said primary and a covves secondary reflector surface consists of a solid transparent optical substrate between said reflectors, said reflectors being comprised of internal reflective surfaces in said optical substrate, said substrate having an outer front and side surface which is convex except for the area occupies by said secondary reflector, said substrate also providing refracting means to extend the field of view of said primary reflector to cover the entire sphere around itself, whereby the front part of said substrate refracts light from an axial point a finite distance in front of said optical system around said secondary reflector surface and toward an inner zone of said primary reflector surface around said secondary reflector surface and toward said inner zone of said primary reflector surface, and whereby the rearward surface of said substrate refracts light from an axial point a finite distance behind the optical system toward the perimeter of said primary reflector surface at an angle which causes said axial point to be in optical communication with said vantage point behind said transparent central zone in said primary reflector surface, said optical system also having an opaque covering around the perimeter of said secondary reflector to act as a light baffle, said optical substrate providing

permanent support and alignment of said reflector surfaces, said solid optical system further comprising refracting optics which are coaxial with said primary reflector and behind said transparent central zone of said primary reflector substrate, said refracting optics correcting for residual aberrations from said solid transparent optical substrate, said primary reflector and said secondary reflector, said corrected aberrations including astigmatism and lateral chromatic aberration; said optics also forming a real image of said virtual image at said focal surface and vice versa, (Remarks: this optical system is that of the title of U.S. provisional application 60/043,701, filed April 16, 1997).

26. apparatus according to claim 1, further comprising a durable rim behind the perimeter of said primary reflector, said rim having a slightly larger diameter than said reflector and, said rim providing protection for said primary reflector and serving as a grip surface to permit handling said primary reflector without soiling the optical surface, said rim also having provision to accurately indicate the limit of coverage for said primary reflector, said rim also being connected to the mounting means for said article having a focal surface, said means for mounting and said rim also having provision for the attachment of accessories such as a clear storage and composition tube, a solar occulting disk, a level and tilt indicator, and data display devices, said level indicator and display devices being directly visible and imaged at said focal surface of said article, (Remarks: if claim 1 is too broad, some of this claim may incorporated into it.)

27. apparatus according to claim 1, further comprising a covering over the perimeter of said primary reflector surface, said covering not being specular, said covering providing means to accurately indicate the limit of coverage for said primary reflector,

28. apparatus according to claim 1, further comprising refracting lenses, said refracting lenses being coaxial with and having a diameter smaller than said primary reflector, said means for mounting including a cell for said refracting optics, said means for mounting positioning said

refracting lenses between said secondary reflector and the focal surface of said article (typically behind said transparent central zone in said primary reflector), and in unobstructed optical communication with both, said refracting optics being in optical communication with said great circle surrounding said primary reflector by means of reflection from said primary reflector and said secondary reflector, said refracting lenses having a longitudinal position corresponding to said vantage point is in optical communication with said great circle and said area in front and behind the plane of said great circle by means of reflection from said secondary reflector and said primary reflector, said longitudinal position of said axial vantage point being varied according to the embodiment and application of said optical system,

29. apparatus according to claim 28, further comprising a filter holder,

30. apparatus according to claim 28, further comprising a series of refracting lenses in interchangeable cells which are each capable of producing a real image from the overall optical system at the focal surface, said cells being of appropriate lengths to produce proper focus and image size at said focal surface when used with the intended articles having a focal surface, said cells also incorporating adaptation and mounting means for appropriate standardized adapters and camera and instrumentation mounting interfaces,

31. apparatus according to claim 28 in which said refracting lenses are capable of producing a real annular image of the virtual image resulting from reflections off said primary reflector and said secondary reflector, said real image being at the focal surface of said article, mounting means for said refracting lenses also providing means for aperture adjustment,

32. apparatus according to claim 31 in which said refracting lenses are of the zoom type, whereby images of different sizes are produced by adjusting the focal length of said zoom lens, whereby the same optical system can be used advantageously with different formats,

33. apparatus according to claim 28 in which said refracting optics (have an exit pupil), said refracting optics cause (paraxial) light rays behind said optical system to be parallel, enabling said optical system to be used in front of an article having a focal plane, where said article has a lens focused at or at a hyperfocal distance slightly closer than infinity, said optical system being compatible with cameras and projectors having fixed lenses.

34. apparatus according to claim 28 in which said refracting lenses (form a real image and) substantially correct curvature of the virtual image resulting from reflections off said primary reflector and said secondary reflector, thereby facilitating the optimum use of a flat focal surface, said refracting lenses typically comprising at least one refracting lens, at least one of which has negative optical power, said negative lens being positioned in relatively close proximity to said focal surface, further, where the application permits, said negative lens may be in contact or virtually in contact with said focal surface, as supported by U.S. provisional application serial number 60/055,876, filed August 15, 1997;

35. apparatus according to claim 34 in which an existing achromatic Barlow lens design is used as the field flattener, (not supported in provisional applications)

36. apparatus according to claim 28 in which said refracting lenses substantially correct aberrations such as off-axis astigmatism which result from off-axis reflections off of said primary reflector and said secondary reflector, as marginally supported by U.S. provisional application serial number 60/055,876, filed August 15, 1997;

37. apparatus according to claim 36 in which said refracting optics include elements having discontinuous aspheric curves, to facilitate higher resolution with a larger aperture and a faster numerical f/ratio, (not supported in provisional applications)

38. apparatus according to claim 28 in which said means for mounting include a central cell, said cell protruding back behind said primary reflector, said protruding cell having a slot around its circumference which may be used to attach accessories and facilitate storage of the overall

optical system in a case without any optical surfaces being in contact with said case, said cell being capable of supporting the weight of the entire optical system, attributes of said cell including said slot providing means to attach devices including a solar occulting disk, a level indicator, and data display devices; said level indicator and display devices being directly visible and imaged at said focal surface of said article having a focal surface, said cell also having provision to house said refracting lenses,

39. apparatus according to claim 1, further comprising an occulting attachment consisting of a small darkened occulting body (typically a sphere) which is affixed to the end of a thin wire of sufficient rigidity to prevent oscillation of said occulting body by wind or moderate motion, said attachment providing for reduction of flare by interrupting specular optical communication between a bright light source such as the sun and the focal surface of said article, said occulting body typically having an angular subtense at least one degree larger than said bright light source as seen from the corresponding area of said virtual image from said primary reflector, thereby causing the image of said occulting body to completely cover said bright light source in the image formed by said optical system, said occultation resulting in a drastic reduction in unwanted reflections and flare; said means for mounting having provision for attaching said occulting attachment to said secondary reflector shield or a rim surrounding said primary reflector, said mounting means also providing for adjustment of said occulting body position,

40. apparatus according to claim 1, further comprising a level indicator which is attached in close proximity to and slightly behind the perimeter of said primary reflector, said level indicator having easily distinguished indication means when observed from above and below, said secondary reflector being larger than what is required to image said primary reflector alone, said secondary reflector shield providing means for optical communication between said level and the focal surface of said article, said level being imaged at said focal surface by means of reflection via said secondary reflector, whereby said level is visible in the viewfinder of a single

lens reflex camera, thereby facilitating effective hand held use of the optical system since the photographer and said camera are behind said primary reflector, as supported by U.S. provisional application serial number 60/055,876, filed August 15, 1997;

41. apparatus according to claim 6, further comprising a periscopic optical system which points directly behind said optical system, said periscopic optical system being attached to said optical system at a point between the back of said primary reflector and the front of said article having a focal surface, said attachment means including a hollow tube, mirrors, and relay optics, said periscopic optical system having a circular field of view greater than the conical exclusion zone behind said primary reflector, the image from said periscopic optical system being imaged at a common focal surface with the annular image from said optical system, but in an area not occupied by said annular image, whereby the overall optical system images the entire sphere around itself on a single focal surface; further, the use of a beam splitter on a transparent support which is in proximity to said focal surface will allow said circular image to be imaged in the center of said annular image,

42. apparatus according to claim 1, associated with (attached to or incorporated into) a camera, photographic optical system, electronic image system, motion picture system, surgical instrument, endoscope, bore scope, surveillance instrument, robotic device, microphone, speaker, or similar article, said article incorporating means for providing omnidirectional illumination of the subject, where and as dictated by the application, subject illumination means being located behind said primary reflector and in front of said secondary reflector, said lighting means being shielded so as not to directly strike the optics in order to reduce flare; and where electronic flash is used, said flash in front of said secondary reflector being triggered by a photosensitive slave sensor in order to eliminate wiring, said flash illumination being compatible with still and motion images (lighting from behind primary addressed in U.S. provisional application 60/043,701; other aspects not fully supported in provisional applications)

43. apparatus according to claim 42, associated with an electronic imaging sensor, provision of subject illumination means also employing a range gated imaging by means of a sensor exposure of only a few to a few dozen nanoseconds, which in turn results in a shorter effective exposure for objects nearest the optical system; further provision thereof in which illumination is initiated prior to the exposure and is actually directed through said optical system by means of a beam splitter prior to the initiation on an exposure.

44. apparatus according to claim 1, further comprising an electronic imaging sensor capable of readout without mechanical shuttering, further comprising imaging and correcting optics, said optical system being capable of imaging said great circle and said area in front and behind the plane of said great circle; said imaging being accomplished without any moving parts;

45. apparatus according to claim 44, said combination also having provision and interface capability to facilitate real time digital processing of more than 24 images per second, whereby said optical system may also be associated with a separate full motion imaging system, (motion pictures covered in both provisional applications, but digital may not have been specified)

46. An optical system comprising:

* a convex specular reflector having radial symmetry,
    * said primary reflector being in optical communication with a great circle surrounding it, said great circle being perpendicular to the optical axis of said primary reflector,
    * said primary reflector having sufficient curvature to be in optical communication with a substantial area in front and behind the plane of said great circle,
* whereby said optical system produces a virtual image of said great circle and said area above and below its plane, said virtual image being annular,

* said virtual image being visible from a vantage point in front of said primary reflector by means of said vantage point being in optical communication with said great circle and said area in front and behind the plane of said great circle by means of reflection from said convex reflector,

* means for mounting and said reflector,

  * said means for mounting providing stable support and alignment of said primary reflector without causing deformation thereof,
  * said means for mounting providing for attachment of said optical system to an article having a focal surface,
  * said article being in front of said reflector,
  * said means providing a shield in close proximity to said article, said shield preventing stray light from entering from the side,
  * said mounting means facilitating unobstructed optical communication between said article and the utilized radial zones of said convex reflector,
  * said optical system typically being associated with a refracting lens system, said refracting lens system being disposed coaxial to said optical system, both being associated with the formation of a real image of said virtual image at said focal surface,

* whereby said optical system combined with said article facilitate the geometric conversion of said great circle and said area in front and behind the plane of said great circle into a real annular image at the focal surface of said article and vice versa,

47. apparatus according to claim 46 in which said convex reflector comprises a surface of revolution, said surface of revolution having a prolate aspheric figure, said prolate aspheric figure also being radially enlarged outward from the optical axis, whereby the surface said convex reflector is closer to perpendicular with the optical axis at a zone which immediately surrounds the reflection of said article having a focal surface, whereby said focal surface is in optical communication with a greater angular area in front of said great circle, thereby reducing the size of the central angular exclusion zone in front of said convex reflector caused by said article,

48. apparatus according to claim 46 in which said convex reflector comprises a surface of revolution, said surface of revolution having a prolate aspheric figure, said prolate aspheric figure also being torroidal as a result of being radially enlarged outward from the optical axis, whereby the surface of said torroidal reflector curves backward in the zone immediately surrounding an area the size of a central obstruction, whereby the radial zone of said torroidal reflector by which the focal surface of said article is in optical communication with an axial point disposed at a finite distance in front of said optical system by means of reflection from said zone of said torroidal reflector has a larger diameter than the obstruction of said article, thereby eliminating the central angular exclusion zone in front of said reflector, the only excluded area being confined to a narrow conical area extending from the perimeter of said article with any associated mounting and shielding to said axial point disposed a finite distance in front of said torroidal reflector,

49. apparatus according to claim 46 in which said convex reflector has a scalloped surface resulting in more than three identical convex lobes disposed evenly around its circumference, each lobe having more than twice the included angle as the angular circumference of the reflector body it occupies; for example, as seen from the front, each lobe of an eight lobe reflector would

occupy 45 degrees of the circumference; therefore, each of said lobes would have more than 90 degrees of curvature as seen from the front; said scalloped reflector providing a sectored virtual image, said image having the same number of sectors as said scalloped reflector has lobes, each of said sectors covering a circumferential angle of view of more than twice the circumferential angle occupied by each sector, whereby said virtual image covers each point in said great circle and said area in front and behind the plane of said great circle at least twice, thereby providing fully redundant coverage thereof; said twice imaged points having circumferentially separated vantage points and being circumferentially separated in said virtual image, said redundant coverage providing three dimensional information for the entire area of coverage, said optical system also being applicable to the projection of sectored images whereby said redundant images overlap and include three dimensional information; the concepts, principles,and geometry of said optical system are also being applicable for the basis of image processing techniques, algorithms, and software which are associated with viewing, analyzing, and otherwise utilizing images produced and reproduced by said optical system, as supported by U.S. provisional application serial number 60/055,876, filed August 15, 1997;

50. apparatus according to claim 46, having a secondary reflector disposed coaxially in front of said convex reflector, said secondary reflector providing optical communication between said convex reflector and an axial vantage point in relatively close proximity to the apex of said convex reflector, said optical system further comprising refracting optics which produce a real annular image of the virtual image from said convex reflector, as reflected in said secondary reflector, said real image being formed at a shielded focal surface in close proximity to the front central surface of said convex reflector,

51. apparatus according to claim 46, further comprising refracting lenses to correct for curvature of the virtual image and aberrations resulting from oblique reflections off said convex

reflector, means for coaxially mounting said refracting lenses in front of said convex reflector, said mounting means including a cell for said refracting lenses and facilitating optical communication between said lenses, said article, and said primary reflector, as marginally supported by U.S. provisional application serial number 60/055,876, filed August 15, 1997;

52. Apparatus according to claim 46 in which said mounting means consist of a single darkened strut, said strut being coaxial with said reflector, said strut having a diameter which is increased toward the end having the greatest distance the focal surface, said strut being coaxially supported in front of said article by means of an optically transparent substrate, whereby the combination of said strut and transparent substrate provide stable support and alignment means for said reflector, whereby said strut is thin enough to facilitate unobstructed optical communication between said article and said convex reflector, and between said convex reflector and said area in front and behind the plane of said great circle, said strut and said transparent substrate being of sufficient thickness to support the full weight of said article, and where required, to support the full weight of said convex reflector, (Remarks: if claim 41 is too broad, this claim may incorporated into it.)

53. apparatus according to claim 52 in which said axial strut extending to near optical center of imaging lenses associated with said article, said hollow strut facilitating the routing of wires without obstructing the subject, whereby said wires are routed from an axial to an off-axis position in close proximity to the optical center of said imaging lenses,

54. apparatus according to claim 46 in which said mounting means for connecting said convex reflector and said article consist of a single vane, said vane being off-axis and having a cross section of less than three degrees when viewed from the optical axis, said vane also having means to route electrical cable and similar articles, said vane further having means to accept an attachment providing means for occulting bright light sources which would otherwise cause

flare; whereby said vane provides stable support and alignment means for an article including said article having a focal surface, (supported by remarks in both provisional applications)

55. apparatus according to claim 46, whereby said optical system is associated with a projector and a cylindrical projection surface to facilitate the geometric conversion of an annular image into a cylindrical projection around said optical system, whereby said convex reflector has a strong aspheric figure which facilitates correct image proportions and substantially constant projection brightness throughout the projection area, said cylindrical projection being applicable to display and printing,

56. apparatus according to claim 46, whereby said optical system is associated with a projector and a spherical projection surface to facilitate the geometric conversion of an annular image into a spherical projection around said optical system, whereby said convex reflector is at the center of said spherical projection surface, said primary reflector having an aspheric figure which facilitates correct image proportions and constant projection brightness throughout the projection area,

57. apparatus according to claim 46, whereby said optical system is associated with a projector and a spherical or semi spherical projection surface to facilitate the geometric conversion of an annular image into a spherical projection around said optical system, whereby said convex reflector is at a position other than the center of said spherical or semi spherical projection surface, said primary reflector having a strong aspheric figure which facilitates correct image proportions and constant projection brightness throughout the projection area in spite of the varying distances to said projection area, said apparatus being applicable to applications including virtual reality games and simulators, as supported by U.S. provisional application serial number 60/055,876, filed August 15, 1997;

58. apparatus according to claim 46, whereby said optical system is used to image, display, and simulate phenomena associated with a total solar eclipse, including terrestrial effects

influenced by the lunar umbra, said optical system being associated with a projector for display of said subject matter by projection, whereby said convex reflector is at a position other than the center of a spherical or semi spherical projection surface, said primary reflector having a strong aspheric figure which facilitates correct image proportions and constant projection brightness throughout the projection area in spite of the varying distances to said projection area, as supported by U.S. provisional application serial number 60/055,876, filed August 15, 1997;

59. apparatus according to claim 57, in which a plurality of said optical systems are utilized to project images into multiple rooms, including multiple portal virtual reality suites and theaters; said apparatus providing for the active masking of projection onto doorways which may be opened and closed, said masking accomplished by means of masks which are positioned in order to obstruct optical communication between an open doorway and the projection source, said masking means having provision to be synchronized with the opening and closing of doors and portals between different rooms; further, a fixed mask may be used where a doorway is always open, said fixed mask being a separate part of a coating such as paint which is applied to the surface of said convex reflector,

60. apparatus according to claim 57, whereby two of said optical systems are associated with a projector and a spherical or semi spherical projection surface, said optical systems being off center and on opposing ends of said spherical projection area, said arrangement facilitating the geometric conversion of two annular images into a spherical projection which covers the entire inside of said spherical projection area without obstructing the center of said projection area or requiring projector light to pass through the center of said spherical projection area, thereby allowing members of an audience to be positioned at and near the center of said projection area, said reflector also having provision for rear projection means onto an area surrounding the back surface of its perimeter, as supported by U.S. provisional application

serial number 60/055,876, filed August 15, 1997;

61. apparatus according to claim 60, further comprising means to suspend members of an audience at and near the center of said projection area, said suspension means having provision for lowering and raising an audience member to and from the floor, the surface of said projection area under the audience being comprised of inexpensive modular sections which can be replaced if soiled by a participant's feet or the results of motion sickness, as supported by U.S. provisional application serial number 60/055,876, filed August 15, 1997.

62. Apparatus and means for geometric conversion of a 360 degree panoramic image into an annular image having polar projection, said apparatus comprising a tilting concave easel which receives unexposed photographic media, said tilted easel having a focal surface which is curved according to a conical surface, said focal surface having the smallest radius of curvature at the top of said easel; said easel being combined with a photographic enlarger having a light source, an enlarging lens of shorter focal length than the lens which photographed the original image, a tiltable lens standard to compensate for tilt of said easel in order to maintain high resolution, and means for accurately securing said easel in optical communication with said enlarging lens; said combination resulting in a greater enlargement of one end of a rectangular section of said panorama when said panorama is projected onto said easel so that its vertical angle of view (assuming the panorama is a conventional horizontal one) is distributed up the vertical tilt of said easel, whereby the resulting image is wedge shaped and borders and lines perpendicular to its vertical dimension are smoothly curved as a result of being projected on said conical surface of said focal surface of said easel, whereby a complete smoothly curved and flat annular image results from assembling a series of wedge shaped images produced by means of said apparatus and means; said apparatus and means also facilitating the incremental geometric conversion of an

annular image into a rectangular or cylindrical image by implementing said means in reverse, whereby wedge shaped areas of the annular image are incrementally converted to a series of rectangular images by projecting the most central part of said annular image onto the bottom end of said tilted concave easel and the outer edge of said annular image onto the top, whereby a complete 360 degree rectangular panorama results from assembling a series of the rectangular images which are produced by means of said apparatus and means; said means also facilitating extraction of limited parts of the original annular image, as supported by U.S. provisional application serial number 60/055,876, filed August 15, 1997;

63. apparatus and means according to claim 62 whereby said geometric conversion of the image is accomplished by exposing photographic media through a slit combined with said tilting easel, said easel also having means to translate the photographic media under said slit, said easel being in optical communication with said photographic enlarger, with said photographic enlarger also having a rotating carrier for the original annular image, whereby the resulting 360 degree image and images extracted therefrom are continuous and seamless, as supported by U.S. provisional application serial number 60/055,876, filed August 15, 1997;

64. apparatus and means according to claim 62, also associated with the use of an image acquired with an optical system having hyperhemispherical coverage to produce said original annular image, said optical system typically incorporating a reflector having a prolate aspheric figure which results in an annular image having substantially increasing radial image scale toward the perimeter of said annular image, whereby use and implementation of said apparatus and means will result in an undistorted 360 degree rectangular panorama and images extracted therefrom, as marginally supported by U.S. provisional application serial number 60/055,876, filed August 15, 1997;

65. apparatus and means according to claim 62 whereby the vertical distribution of the resulting converted image is manipulated by means of reimaging said converted image on a cylindrical easel having a local axis which is perpendicular to that of the axis of said conical surface easel, said axis of cylindrical easel being locally parallel to the horizon on a conventional horizontal panorama (not supported in provisional applications)

66. apparatus and means according to claim 62 whereby geometric conversion of the image is also accomplished by exposing photographic media through a slit combined with said tilting easel, said easel also having means to translate the photographic media under said slit, said easel also having means to warp the photographic media and said slit in the direction perpendicular to its motion; said easel being in optical communication with said photographic enlarger, said photographic enlarger also having a rotating carrier for an original annular image, whereby the resulting 360 degree image and images extracted therefrom are continuous and seamless (not supported in provisional applications)

67. apparatus and means according to claim 66, also associated with the use of an image acquired with an optical system having hyperhemispherical coverage to produce said original annular image, said optical system typically incorporating a reflector having a prolate aspheric figure which results in an annular image having a constant radial image scale, whereby use and implementation of said apparatus and means will result in a substantially undistorted 360 degree rectangular panorama and images extracted therefrom, (not supported in provisional applications)

68. apparatus and means according to claim 62 also comprising a linear gradient neutral density filter to substantially compensate for the range of brightness due to differing lens to easel distances and the range of angles at which the light from the image source impinges on the easel, whereby the density resulting projected image is substantially constant, whereby the density of resulting print or film is substantially consistent, (supported by dwg. text in prov.)

69. apparatus and means according to claim 62 also comprising active linear dodging and active color filtration means, said active filtration means being accomplished by registering appropriate color printing filters with a dodging mask in such a way that both said filters and said mask can be moved together, whereby the edges of said filters precede the leading edge of said dodging mask as said registered assembly is moved between said photographic enlarger and said easel; said active filtration providing means to compensate for reciprocity failure in the photographic media resulting by the variable exposure time which is required due to the pronounced tilt of said easel, whereby the density of a resulting print or film is substantial consistent, as supported by U.S. provisional application serial number 60/055,876, filed August 15, 1997;

70. geometric conversion of an annular image into a rectangular panorama and smaller elements according to concepts, principles and algorithms based on the geometry, concepts, principles, algorithms, and techniques associated with the apparatus and means of claim 62, said algorithms also being incorporated into image processing software, said software also providing means to accommodate wider vertical angles than said apparatus and means according to simulation of enlarging optics having a wider field of view and closer working distances than those commercially available, said software also not causing unwanted local changes in density due to the fact that differing enlargement ratios do not affect density since photographic media is not involved in mathematical conversion, (not specifically supported in provisional applications)

71. geometric conversion of an annular image into a rectangular panorama and smaller elements according to concepts, principles and algorithms based on the geometry, concepts, principles, and techniques associated with the apparatus and means in claim 67, said apparatus and means also including the application of said hyperhemispherical optical system in converting an annular image to a cylindrical image by projecting said annular image onto a the

inside of a surface of revolution, said algorithms also being incorporated into image processing software, said software also providing means to accommodate wider vertical angles than said apparatus and means according to simulation of enlarging optics having a wider field of view and closer operating distances than is possible with physical commercially available optics, said software also not causing unwanted local changes in density due to the fact that differing enlargement ratios do not affect density where photographic media is not involved, said software also facilitating virtually simultaneous implementation of the entire process, thereby making it applicable to still and full motion images, (not specifically supported in provisional applications)

72. digital image processing according to claim 71, providing digital image manipulation means for the geometric conversion of an annular image into a distorted or undistorted rectangular format and vice versa, said digital image manipulation means also providing for the extraction undistorted images of smaller segments; said digital image manipulation means analogous to stretching the annular image into a cylinder or cutting said annular image in a radial direction and implementing progressively greater circumferential expansion of said annular image data from the outer circumference toward the center, whereby the inward part of the image is expanded until its circumference matches that of the outer circumference, thereby resulting in a seamless rectangular image of the entire annular image and elements thereof, said processing also applicable to a polar projection annular image having true omnidirectional full sphere coverage, (not specifically supported in provisional applications, though it is analogous to supported darkroom process)

73. digital image processing according to claim 72 whereby circumferential expansion is accomplished by adding pixels at regular intervals, said pixels which repeating the data of those immediately surrounding them, (not supported in provisional applications, though it is mentioned for linear applications in the applicant's prior art reference number 7)

74. digital image processing according to claim 72 whereby circumferential expansion is accomplished by adding pixels at regular intervals, said pixels repeating the data of those immediately surrounding them, said circumferential expansion being accompanied or replaced by progressive circumferential compression of the outer zones of the image by subtracting pixels inneach row at regular intervals, (not supported in provisional applications, though it is mentioned for linear applications in the applicant's prior art reference number 7)

75. digital image processing according to claim 74, also providing means to correct for errors in pointing the original wide angle image acquisition device, whereby said pointing errors result in a great circle (typically the horizon being imaged as an ellipse, said ellipse being corrected by slight compression of the entire image along the long dimension of said ellipse, resulting in restoration of a circular image of said great circle; after which, the center of said circle is referenced as the center of the overall annular image, (as suported in information disclosure reference number 30 in U.S. provisional application serial number 60/055,876, filed August 15, 1997, said reference being authored by the applicant)

76. digital image processing according to claim 75, also providing means to facilitate continuous panning through a seamless image by changing the circumferential position of said imaginary radial cut, further providing for repetition of pixel columns in the direction a viewer desires to pan and extend the image, whereby the image may exceed 360 degrees, said processing further providing means to automatically implement pointing error correction based on data in the image which may include a level indicator, (not supported in provisional applications)

77. digital image processing according to claim 75, whereby the proportions of the subject matter in the center of the resulting rectangular image are determined by the selected radial zone of unity expansion in the annular image; for example, where the horizontal image scale is to match the vertical image scale, the selected zone of unity expansion is the the radial zone of the

annular image having a diameter equal to the desired horizontal length of the image divided by pi. (not supported in provisional applications)

78. digital image processing according to claim 75, whereby the image is manipulated in real time with the use of a high speed computer, said digital image manipulation resulting in the display of more than 24 processed frames per second for full motion applications at various resolutions, (not supported in provisional applications)

79. digital image processing according to claim 75, also having provision to manipulate the vertical linearity of the image by means analogous to tilting an easel, translating the easel, warping the easel, and utilizing an enlarging lens having projection characteristics other than rectilinear, (not supported in provisional applications)

80. digital image processing according to claim 75, whereby said digital image manipulation means are capable of converting a contiguous polar projection circular image having true omnidirectional full sphere coverage (as opposed to an annular image) into a rectangular format; said digital image manipulation means progressively enlarging the inner zones of the image to a progressively greater degree, with the central pixel data being repeated across the entire top pixel row of the resulting rectangular image, said rectangular image covering at least 180 by 360 degrees, (not supported in provisional applications)

81. digital image processing according to claim 75, whereby the observer can view positions directly above and below the vantage point by means of utilizing said digital image manipulation means to convert all necessary elements of the rectangular image into a polar projection image, said image manipulation means also having provision to insert a separate image into the conical exclusion zone of an image not having full sphere coverage, said said image manipulation means also being compatible with cylindrical and spherical images made up from a plurality of images having angles of view less than 180 degrees, (not supported in provisional applications)

(Early versions of the Livepicture's PhotoVista program may be applicable as prior art)

82. digital image processing according to claim 75, also providing for control of distortion by means of an algorithm analogous to projecting an original transparent cylindrical image surface onto a flat surface with a linear light source which is coaxial with said cylindrical image, each row or column of said image only being influenced by the point of said cylindrical light source which is on the same plane with it, said light source said cylindrical to planar conversion resulting in a rectangular image having increasing image scale above and below a specified central line (typically a horizontal line such as the horizon), said expansion being equal to the reciprocal of the cosine of the angle above and below the center, resulting in an image having the same geometrical characteristics an image produced with a rotating panoramic camera having a rectilinear lens (not supported in provisional applications)

83. digital image processing according to claim 75, also providing for control of distortion by means of an algorithm analogous to projecting an original transparent spherical image surface onto a flat surface with a point light source, said spherical to planar conversion resulting in a rectangular image having increasing image scale in all directions from a specified point, said expansion being radial to said specified point and equal to the reciprocal of the cosine of the angle from said specified point, resulting in an image of limited coverage having the same geometrical characteristics as an image produced by a rectilinear lens, said geometrical characteristics also being the same as same the image projection characteristics as a pinhole camera having a flat focal plane. (not supported in provisional applications)

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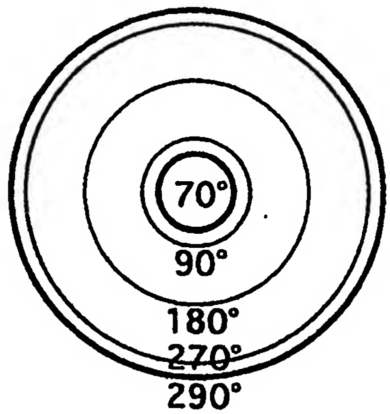

FIG. 1
ANNULAR IMAGE FROM PROLATE ASPHERIC REFLECTOR

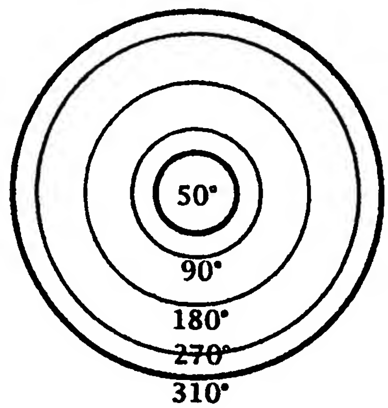

FIG. 2
ANNULAR IMAGE FROM RADIALLY ENLARGED ASPHERIC REFLECTOR

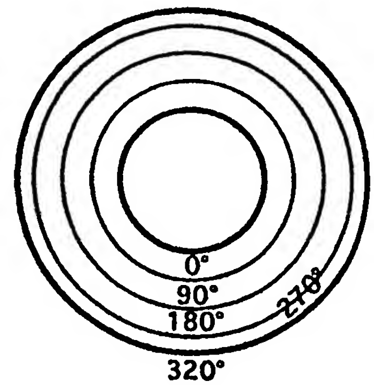

FIG. 3
ANNULAR IMAGE FROM TORROIDAL PROLATE ASPHERIC REFLECTOR

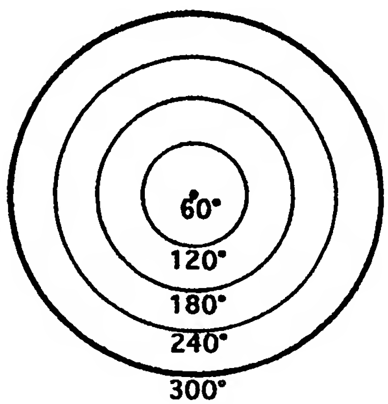

FIG. 4
CIRCULAR IMAGE FROM REFLECTOR HAVING POINTED APEX

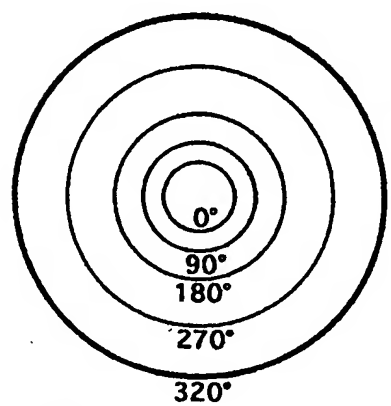

FIG. 5
RADIALLY INCREASING IMAGE SCALE FOR OFF-CENTER PROJECTOR

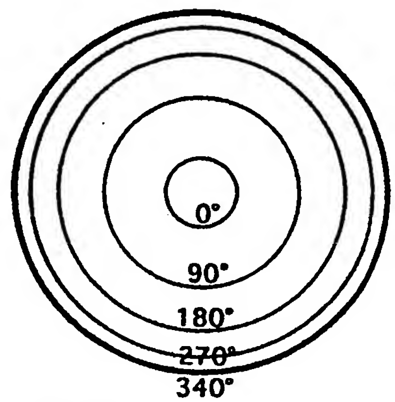

FIG. 6
RADIALLY DECREASING IMAGE SCALE FOR OFF-CENTER PROJECTOR

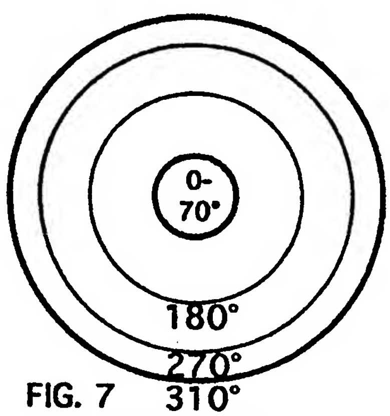

FIG. 7
CIRCULAR COVERAGE WITH MERGED COVERAGE FROM CENTRAL LENS

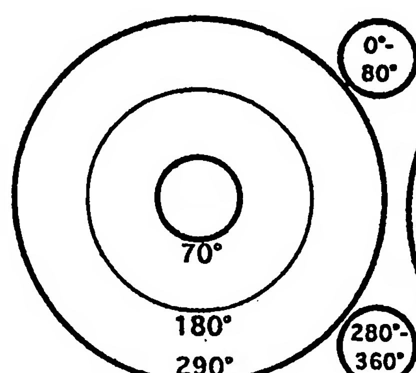

FIG. 8
CENTRAL, REAR COVERAGE FROM AUXILIARY PERISCOPIC OPTICS

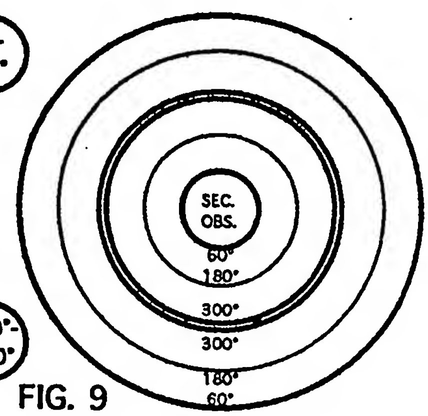

FIG. 9
THREE DIMENSIONAL IMAGE FROM ANNULAR REFLECTOR AROUND SECONDARY

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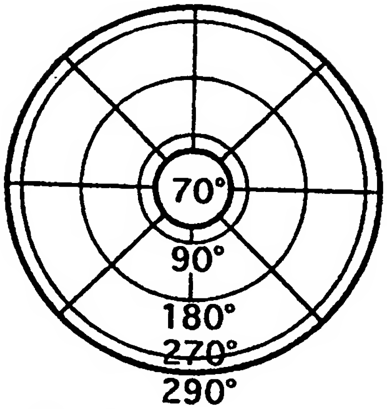

FIG. 10
SECTORED ANNULAR IMAGE FROM SCALLOPED PROLATE ASPHERIC REFLECTOR

45 degree sectors shown for example, each of which covers more than 90 degrees, for redundant imaging for 3D.

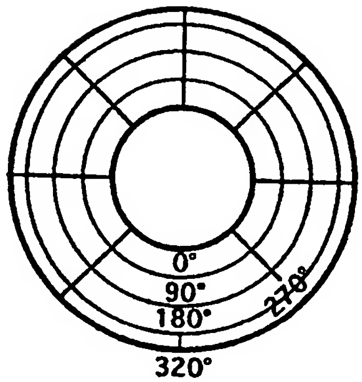

FIG. 11
ANNULAR IMAGE FROM SCALLOPED TORROIDAL PROLATE ASPHERIC REFLECTOR

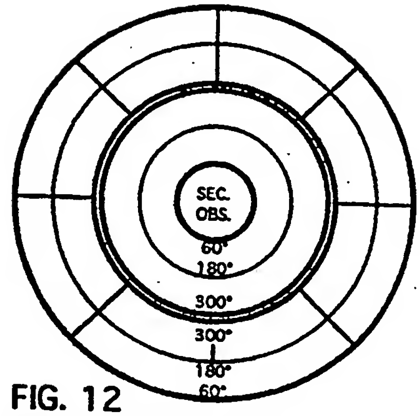

FIG. 12
MULTIPLE AXIS THREE DIMENSIONAL ANNULAR IMAGE FROM SCALLOPED ANNULAR REFLECTOR AROUND SECONDARY

A matrix of suites can be used for a large number of combinations.

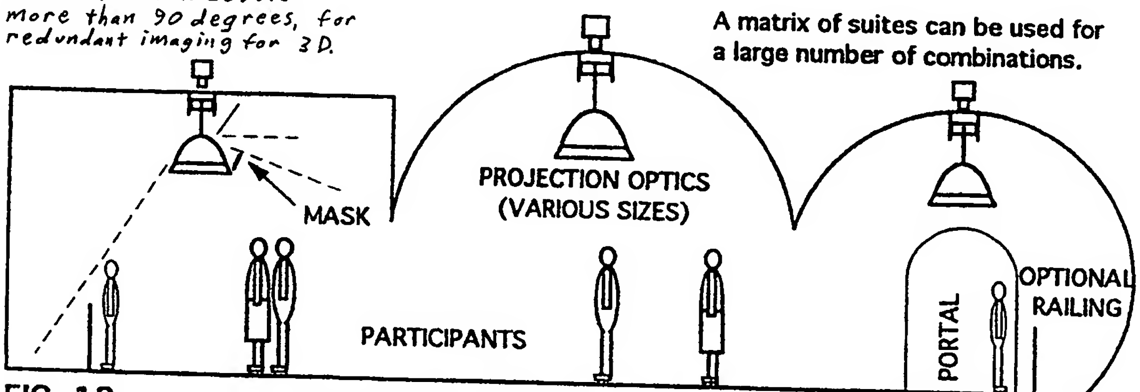

FIG. 13
VIRTUAL REALITY PROJECTION SUITE

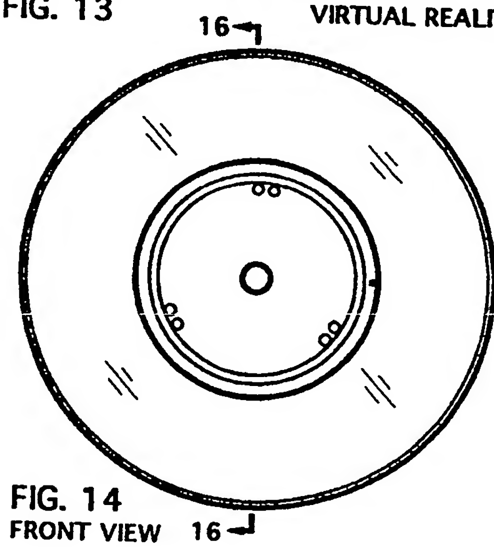

FIG. 14
FRONT VIEW

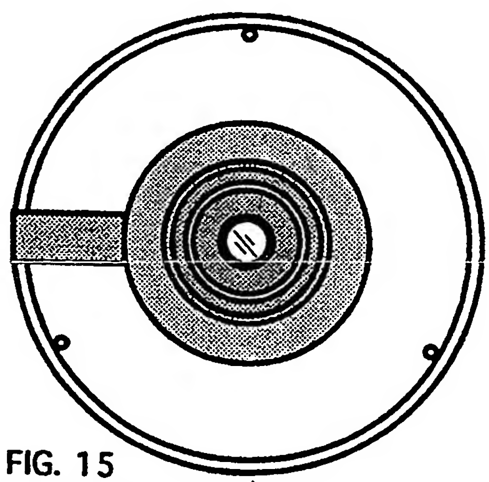

FIG. 15
REAR VIEW

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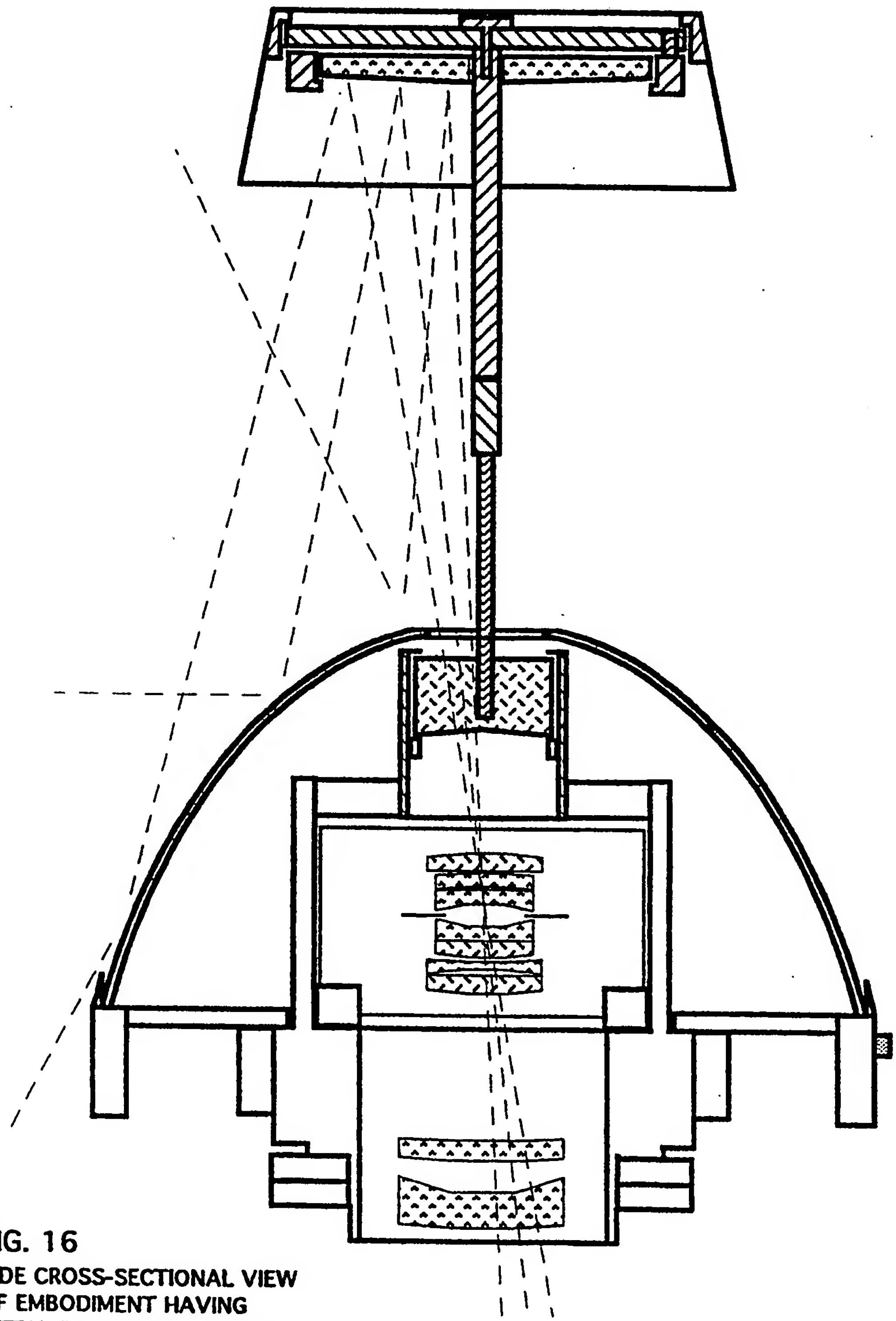
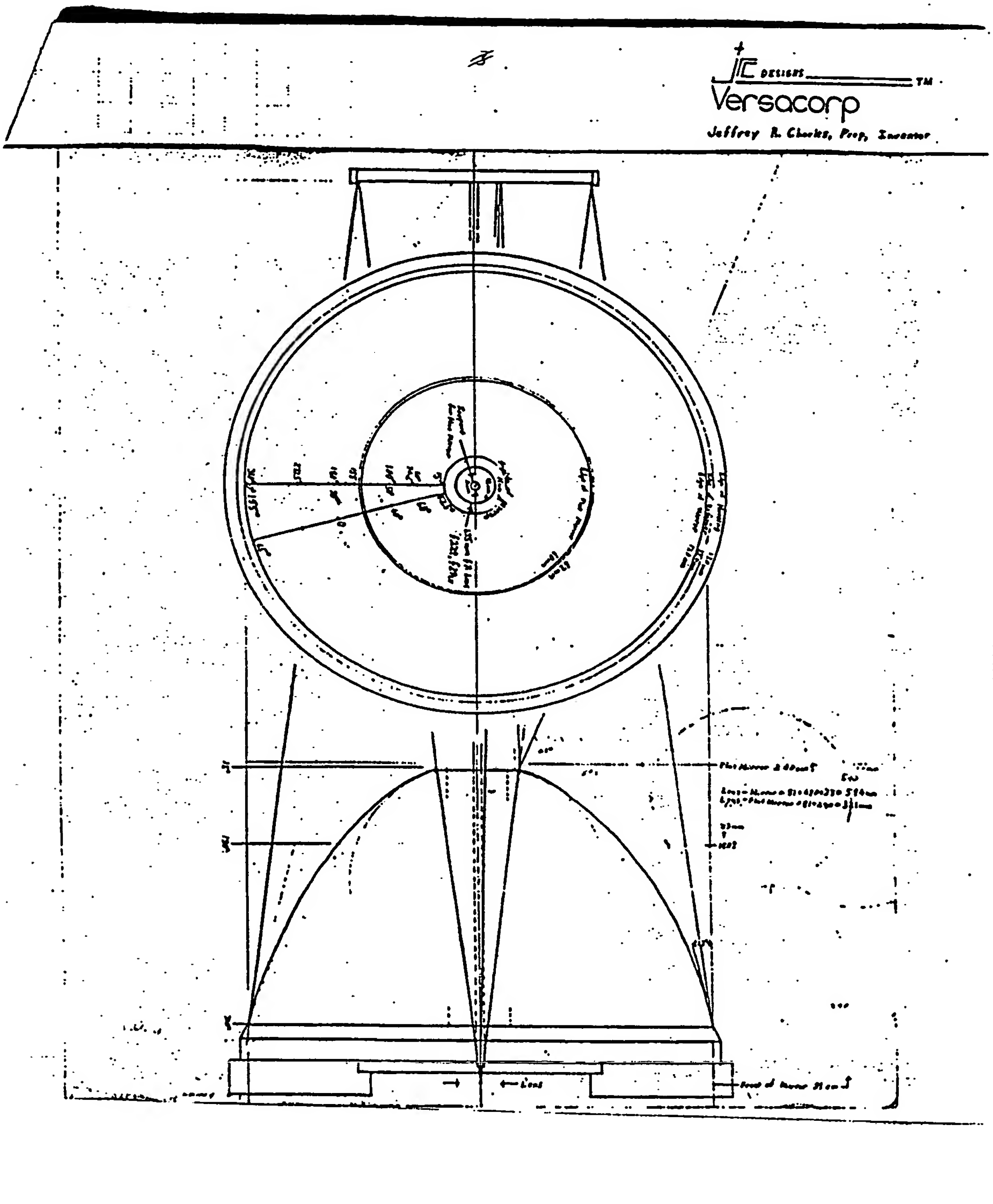


FIG. 16

SIDE CROSS-SECTIONAL VIEW OF EMBODIMENT HAVING METAL REFLECTOR, TAKEN ALONG LINE 16-16 OF FIG. 14

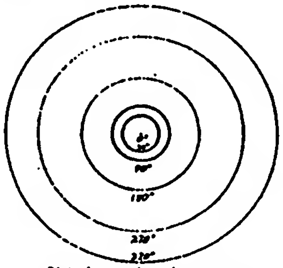

DESIGNS
TM
Versacorp
Jeffrey R. Charles, Prop, Inventor

JC DESIGNS TM
Versacorp
Jeffrey R. Charles, Prop, Inventor

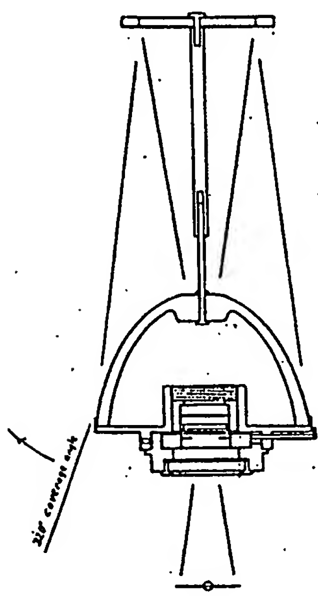
Prior art:

- Soligor 180° circular field Fisheye Lens Attachment, first seen in January, 1976
- Nikon 6mm f2.8 and 5.6 lenses; 220° coverage, first seen advertised in 1976. Were available before then.
- Spiratone "Bird's Eye" wide angle reflecting lens attachment, first seen advertised in July, 1976. Uses one reflection and cylindrical glass support.
- Large silver plastic hose containers, first seen in May, 1978
- Shiny silver spherical Christmas ornaments.

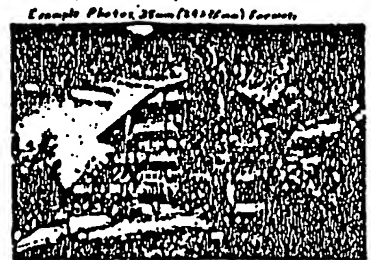
Present Invention:



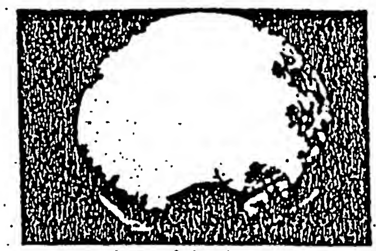
Distribution of angular coverage.



Example Photos: 35mm (24x36mm) Format.



Conventional 20mm rectilinear wide angle - 94°



Conventional 7.5mm fisheye lens, 180° coverage - inadequate for coverage of entire horizon and has vertical compression toward edge.

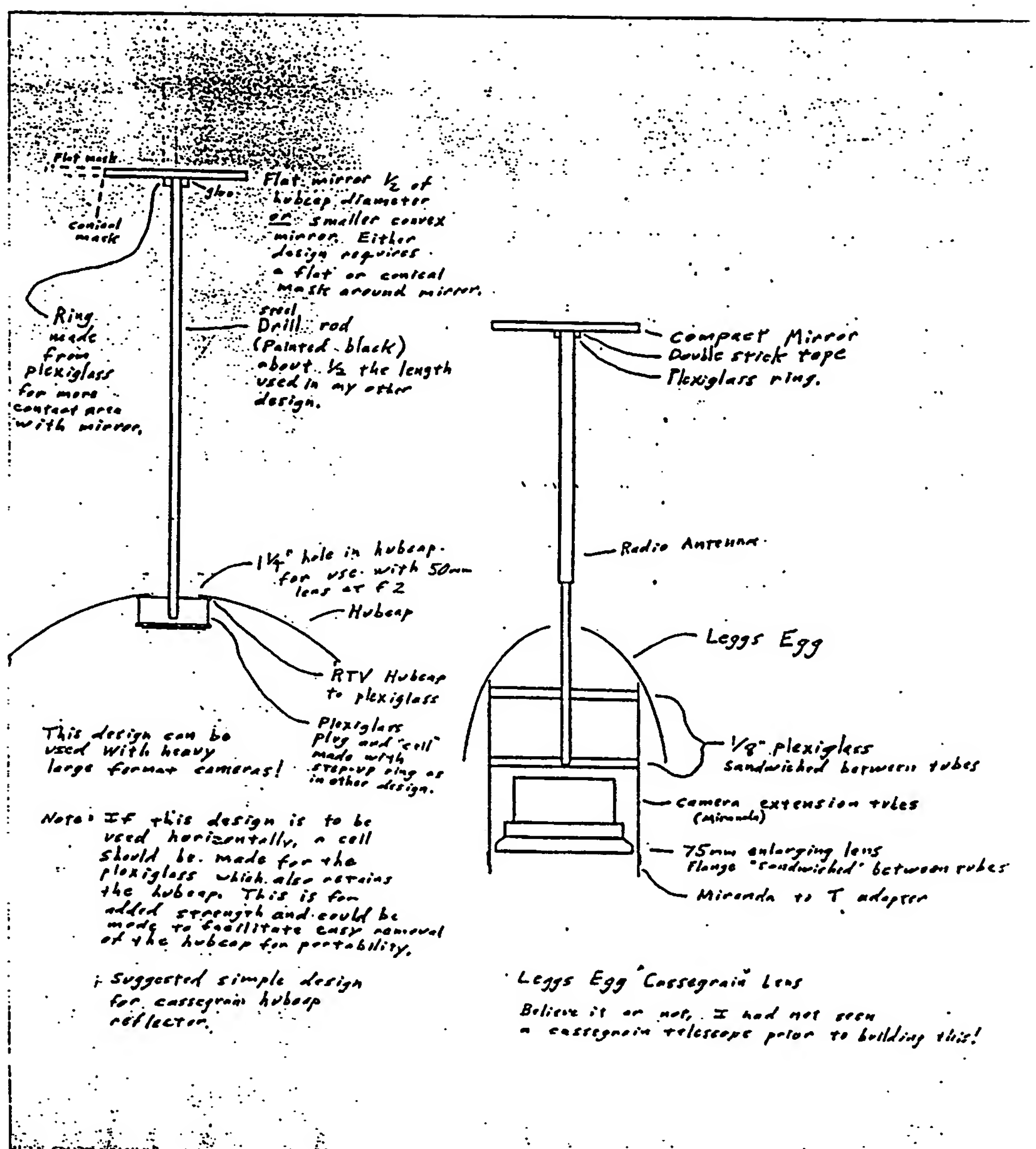
Spiratone "Bird's Eye" attachment, 225° coverage. Produces reversed images, has flare from glass support cylinder, and must be inverted for sky to be in center of picture.

Present invention - early prototype with 240° coverage, is pointed "up" for sky to be in center, produces unreversed image with minimal flare and distortion. 8.5-6mm for 35mm format.

Claimed as new:

1. The present invention is a self-contained refracting and reflecting lens, rather than an attachment for a lens but its concept is applicable to such an attachment.
2. 2 reflections are used, resulting in an unreversed image, and allowing a camera to be used underneath this invention when recording an image with "up" in the center.
3. Support and focus rod for plane, or secondary, mirror is of slim construction and is in line with the optical axis of the invention, therefore it is not visible in the final image. This type of support does not introduce the image degrading reflections and flare associated with transparent cylindrical enclosure type supports.

Invention: Extreme wide angle reflecting lens having a 320° unreversed circular angle of view with minimal proportional distortion.
Conceived and prototype built using back of projector bulb reflector for wide angle reflector in August, 1977 by myself, Jeffrey R. Charles.


Flat mask
conical mask
glue
Flat mirror ½ of hubcap diameter or smaller convex mirror. Either design requires a flat or conical mask around mirror.
Ring made from plexiglass for more contact area with mirror.
steel Drill rod (Painted black) about ½ the length used in my other design.
1¼" hole in hubcap. for use with 50mm lens at f2
Hubcap
RTV Hubcap to plexiglass
Plexiglass plug and "cell" made with step-up ring as in other design.
This design can be used with heavy large format cameras!
Note: If this design is to be used horizontally, a cell should be made for the plexiglass which also retains the hubcap. This is for added strength and could be made to facilitate easy removal of the hubcap for portability.
Suggested simple design for cassegrain hubcap reflector.
Compact Mirror
Double stick tape
Plexiglass ring.
Radio Antenna
Leggs Egg
1/8" plexiglass sandwiched between tubes
Camera extension tubes (Miranda)
75mm enlarging lens flange "sandwiched" between tubes
Miranda to T adapter
Leggs Egg "Cassegrain" Lens
Believe it or not, I had not seen a cassegrain telescope prior to building this!

5

Versacorp

Jeffrey R. Charles, Prop, Inventor

Prior Art:

- Soligor 180° circular field Fishey Lens Attachment, first seen January, 1976
- Spiratone "Bird's Eye" wide angle reflecting lens attachment, first seen advertised in July, 1976, uses cylindrical glass support.
- Nikon 6mm f 2.8 and 5.6 lenses, 220° coverage, first seen advertised in 1978, were available before then.
- Leggs silver plastic hose containers, first seen in May, 1978.
- Shiny silver spherical Christmas ornaments
- Shiny radiused hubcaps
- Hubcap "all sky" lens made by Chris Schur of Black Canyon City, Az. Uses 3 support legs for camera.
- Dish antenna.
- Open tube cassegrain telescopes, and "tubeless" compact cassegrain telescope.
- Extreme wide angle reflecting lens designed and built by myself, Jeffrey R. Charles, in Aug. 1977.
- Photo copy stand.

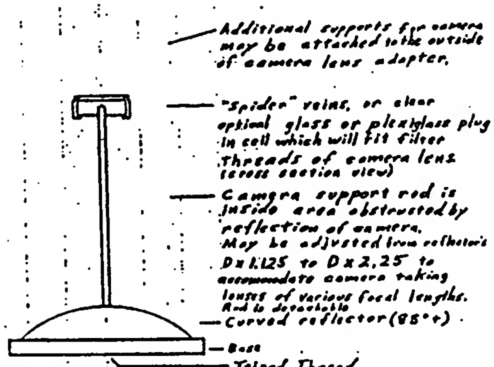


Fig. 1A "Invisible" support in center

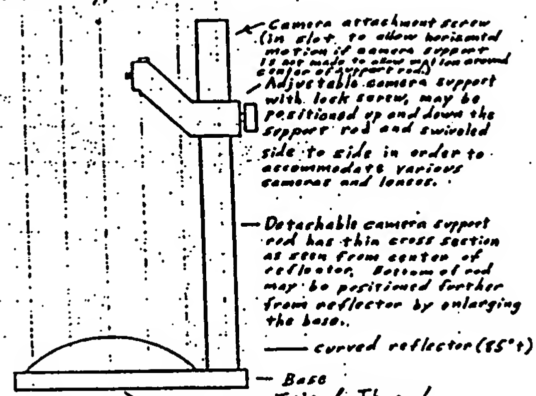


Fig. 1B Single support arm to side.

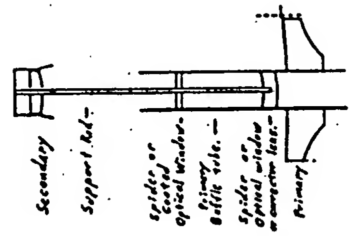


Fig. 2A Center support rod (cross section)

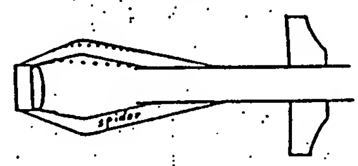


Fig 2B "Inside" 3-4 vein spider. (cross section)

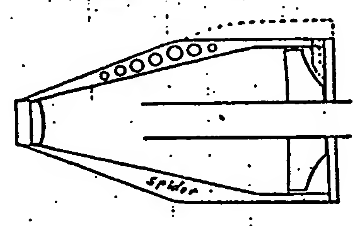
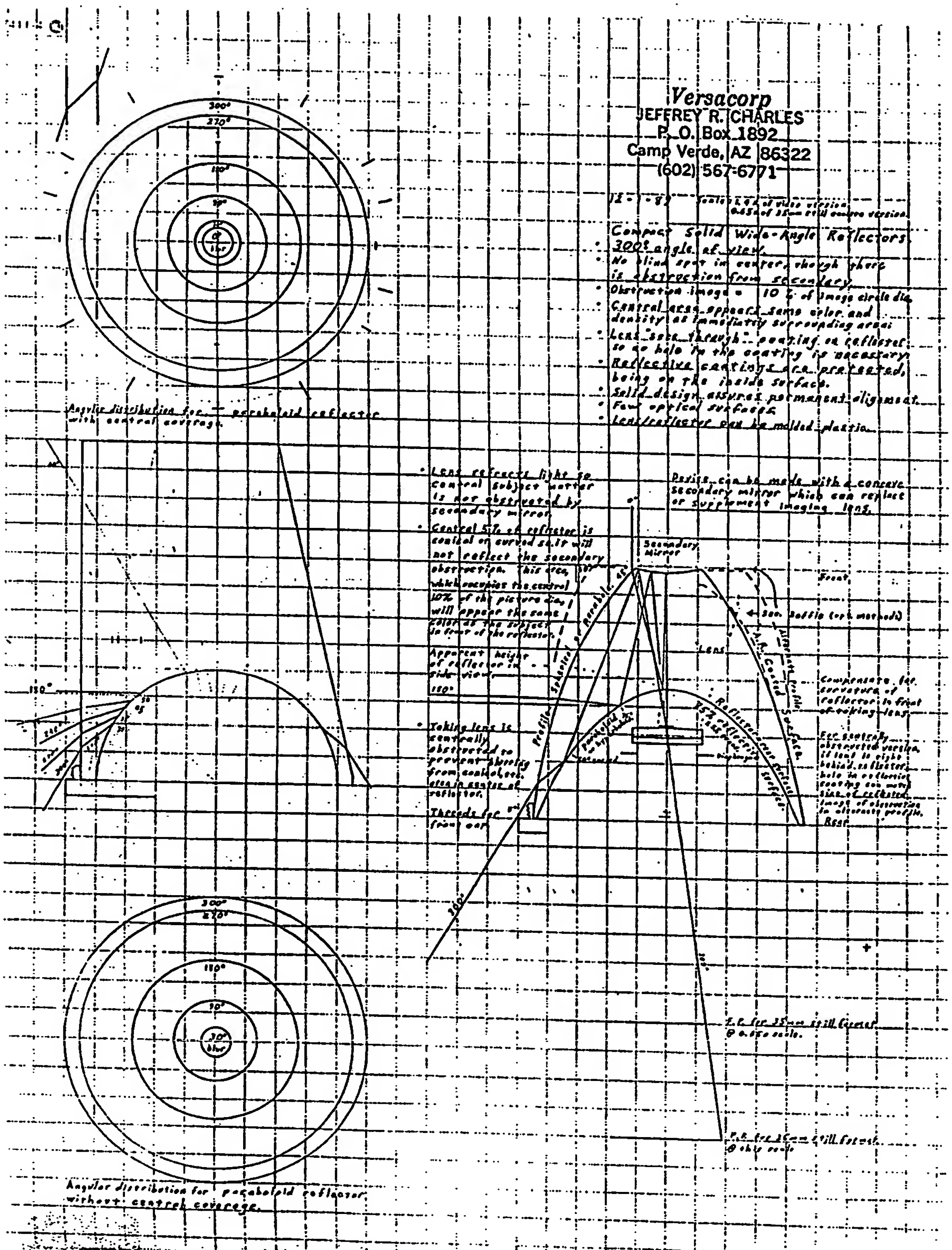


Fig 2C Outside 3-4 vein spider (cross section).

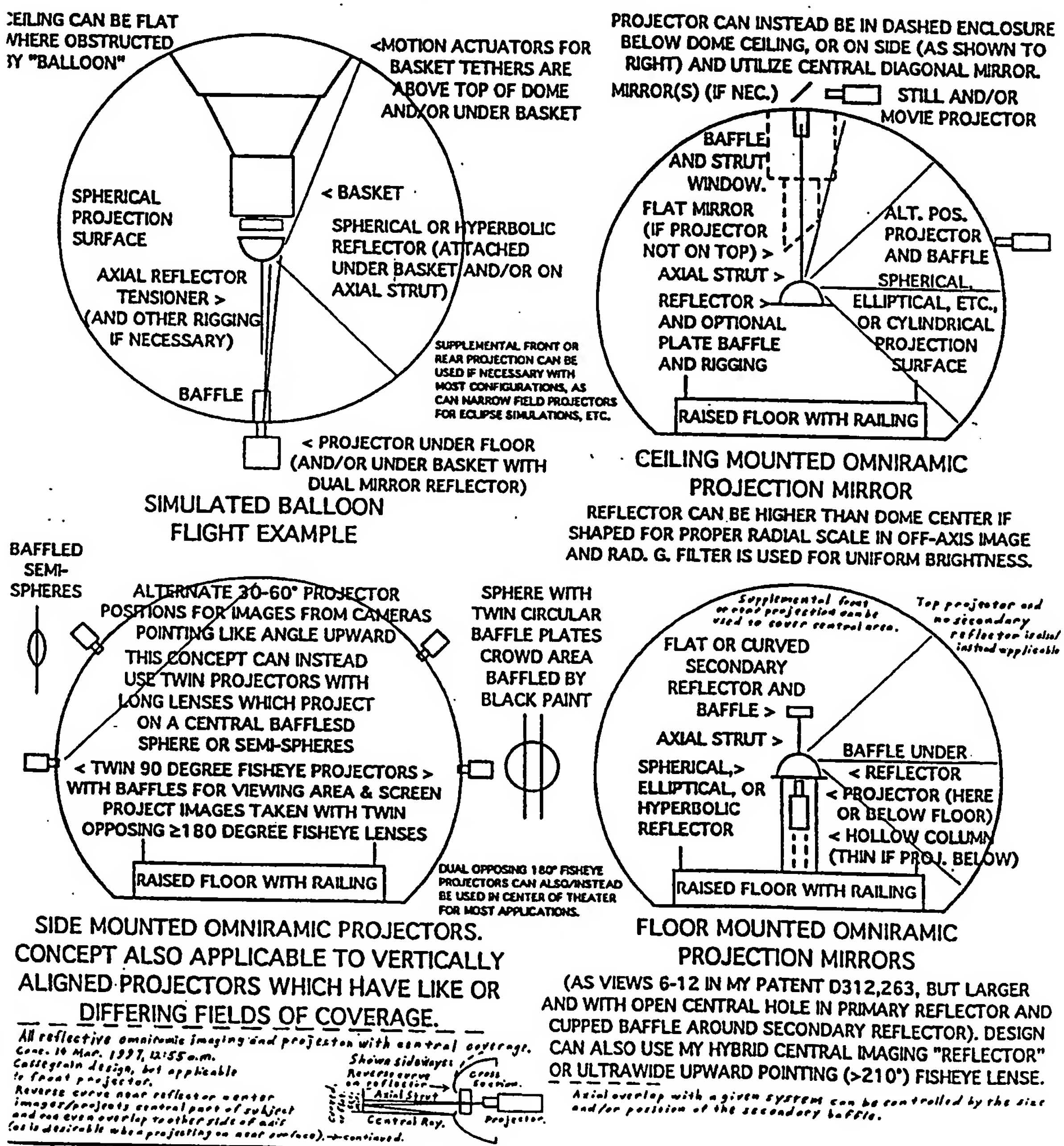
Invention: New Designs for 180°+ "All sky" wide angle reflecting lens. (Figs 1A and 1B) Conc. 5-14-86
New Designs for secondary mirror support on cassegrain telescope. (Figs. 2A-2C) Conc. 10-84

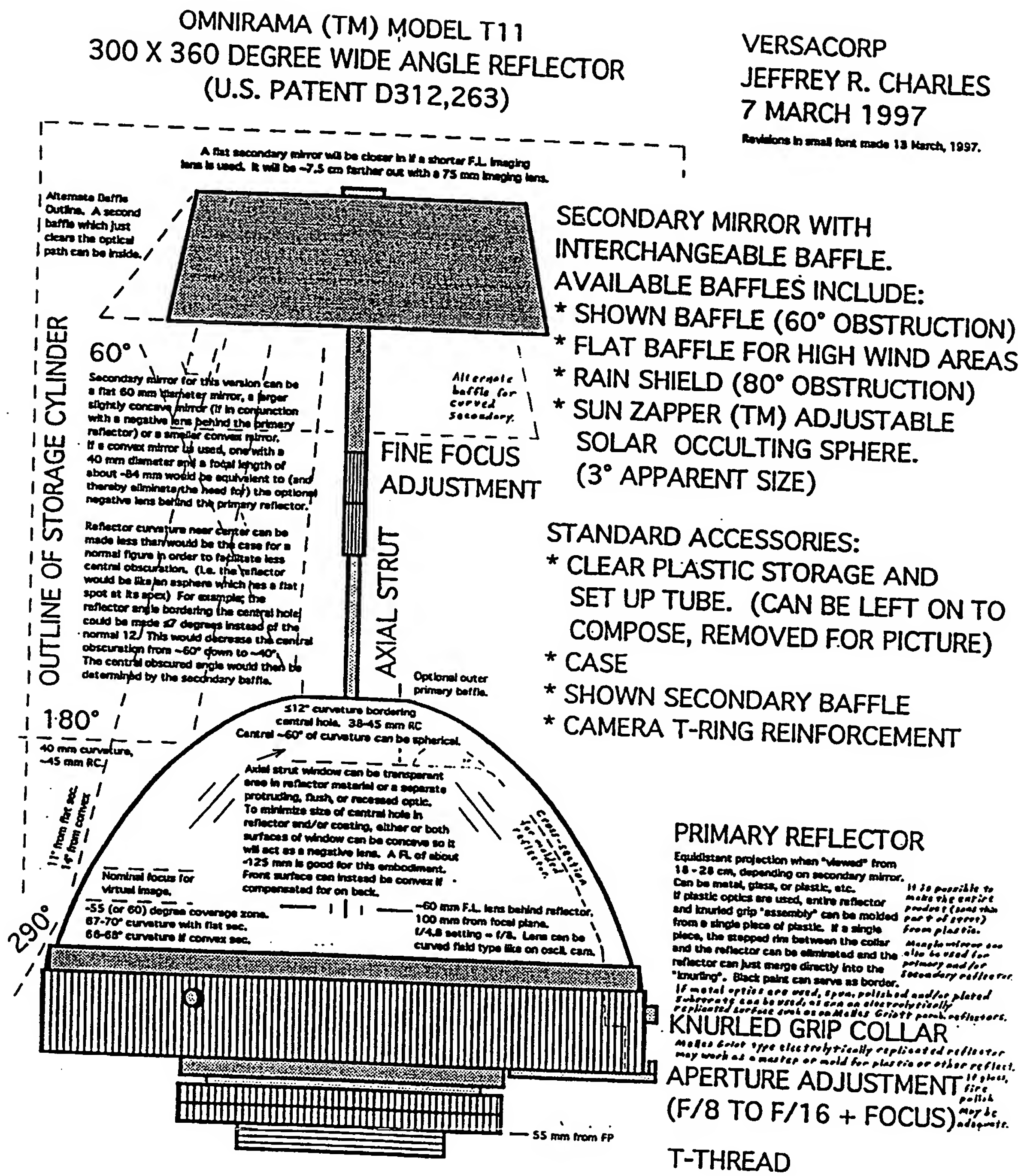

Versacorp
JEFFREY R. CHARLES
P. O. Box 1892
Camp Verde, AZ 86322
(602) 567-6771
Compact Solid Wide-Angle Reflectors
300° angle of view.
Obstruction image = 10 % of image circle dia.
Central area appears same color and density as immediately surrounding areas
Solid design assures permanent alignment.
Few optical surfaces
Device can be made with a concave secondary mirror which can replace or supplement imaging lens.
Lens refracts light so central subject matter is not obstructed by secondary mirror.
Secondary Mirror
Front
Baffle
Lens
Apparent height of reflector in side view
180°
Rear
300°
270°
180°
90°
30°
Angular distribution for paraboloid reflector with central coverage.
Angular distribution for paraboloid reflector without central coverage.

INVENTIONS:
PANORAMIC AND OMNIRAMIC PRESENTATION
FOR SIMULATIONS OF FLIGHT, SOLAR ECLIPSES, AND OTHER EVENTS.
(MANY EMBODIMANTS USE MY AXIAL STRUT REFLECTOR INVENTION:
U.S. PATENT NO. D312,263) (NOT NECESSARILY SHOWN TO SCALE)

VERSACORP
JEFFREY R. CHARLES
6 MARCH 1997
OMNIRAMA (TM) AND
VERSARAMA (TM),
PROJECTION SYSTEMS

OMNIRAMIC PROJECTION BOOTHS, SUITES, THEATERS:

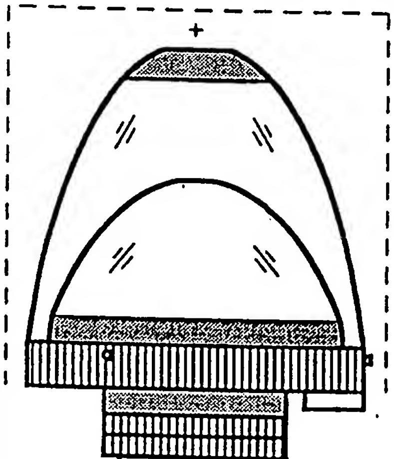



OMNIRAMA (TM) MODEL T11
300 X 360 DEGREE WIDE ANGLE REFLECTOR
(U.S. PATENT D312,263)
VERSACORP
JEFFREY R. CHARLES
7 MARCH 1997
Revisions in small font made 13 March, 1997.
A flat secondary mirror will be closer in if a shorter F.L. imaging lens is used. It will be ~7.5 cm farther out with a 75 mm imaging lens.
Alternate Baffle Outline. A second baffle which just clears the optical path can be inside.
SECONDARY MIRROR WITH INTERCHANGEABLE BAFFLE.
AVAILABLE BAFFLES INCLUDE:
* SHOWN BAFFLE (60° OBSTRUCTION)
* FLAT BAFFLE FOR HIGH WIND AREAS
* RAIN SHIELD (80° OBSTRUCTION)
* SUN ZAPPER (TM) ADJUSTABLE SOLAR OCCULTING SPHERE. (3° APPARENT SIZE)
60°
OUTLINE OF STORAGE CYLINDER
Secondary mirror for this version can be a flat 60 mm diameter mirror, a larger slightly concave mirror (if in conjunction with a negative lens behind the primary reflector) or a smaller convex mirror. If a convex mirror is used, one with a 40 mm diameter and a focal length of about -84 mm would be equivalent to (and thereby eliminate the need for) the optional negative lens behind the primary reflector.
Reflector curvature near center can be made less than would be the case for a normal figure in order to facilitate less central obscuration. (I.e. the reflector would be like an asphere which has a flat spot at its apex) For example, the reflector angle bordering the central hole could be made ≤7 degrees instead of the normal 12. This would decrease the central obscuration from ~60° down to ~40°. The central obscured angle would then be determined by the secondary baffle.
Alternate baffle for curved secondary.
FINE FOCUS ADJUSTMENT
AXIAL STRUT
STANDARD ACCESSORIES:
* CLEAR PLASTIC STORAGE AND SET UP TUBE. (CAN BE LEFT ON TO COMPOSE, REMOVED FOR PICTURE)
* CASE
* SHOWN SECONDARY BAFFLE
* CAMERA T-RING REINFORCEMENT
Optional outer primary baffle.
180°
40 mm curvature, ~45 mm RC.
≤12° curvature bordering central hole. 38-45 mm RC
Central ~60° of curvature can be spherical.
Axial strut window can be transparent area in reflector material or a separate protruding, flush, or recessed optic. To minimize size of central hole in reflector and/or coating, either or both surfaces of window can be concave so it will act as a negative lens. A F.L. of about -125 mm is good for this embodiment. Front surface can instead be convex if compensated for on back.
Cross-section for molded reflector.
11° from flat sec.
14° from convex
Nominal focus for virtual image.
290°
-55 (or 60) degree coverage zone. 67-70° curvature with flat sec. 66-68° curvature if convex sec.
~60 mm F.L. lens behind reflector, 100 mm from focal plane. f/4.8 setting = f/8. Lens can be curved field type like on oscil. cam.
PRIMARY REFLECTOR
Equidistant projection when "viewed" from 18-28 cm, depending on secondary mirror. Can be metal, glass, or plastic, etc. If plastic optics are used, entire reflector and knurled grip "assembly" can be molded from a single piece of plastic. If a single piece, the stepped rim between the collar and the reflector can be eliminated and the reflector can just merge directly into the "knurling". Black paint can serve as border.
It is possible to make the entire product (sans this part of strut) from plastic.
Mangin mirror can also be used for primary and/or secondary reflector.
If metal optics are used, spun, polished and/or plated substrates can be used, as can an electrolytically replicated surface such as on Melles Griot parab. reflectors.
KNURLED GRIP COLLAR
Melles Griot type electrolytically replicated reflector may work as a master or mold for plastic or other reflect.
APERTURE ADJUSTMENT
(F/8 TO F/16 + FOCUS)
If glass, fire polish may be adequate.
55 mm from FP
T-THREAD

OMNIRAMA (TM) OMNILENS (TM) MODELS SC AND SCL 5 & 6
340 (or even 360) X 360 DEGREE SOLID CATADIOPTRIC WIDE
ANGLE REFLECTORS WITH CENTRAL COVERAGE FOR VIDEO, ETC.
(SCL MODELS HAVE REDUNDANT OR MERGED CENTRAL COVERAGE)
ALL VERSIONS ARE APPLICABLE TO ORIGINAL IMAGING AND TO PRINTING, PROJECTION, ETC.

VERSACORP
JEFFREY R. CHARLES
24 MARCH 1997

Reflector curvature near center can be made less than what a normal figure would be in order to facilitate less angular obscuration by its central hole. (i.e. the reflector could be like an asphere which has a flat spot at its apex). In most cases, this would allow the outer part of the optic to be shorter.



< SECONDARY MIRROR WITH PAINTED BAFFLE.

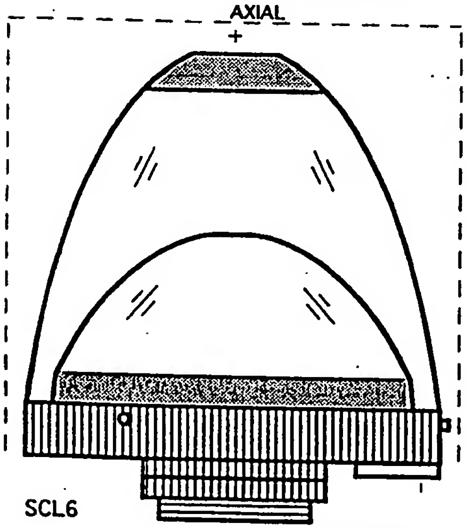
SPECIFICATIONS:
ANGLE OF VIEW: 340° (360° POSSIBLE IF NO DRAFT IN DIES)
ANGULAR CENTRAL OBSTRUCTION: NONE
IMAGED OBSTRUCTION: 20% DIA. (SCL version with merged central image has none)
PROJECTION: RADIALLY EQUIDISTANT
RADIAL IMAGE SCALE: 88° per mm (SCL with merged central image = 70° per mm)
IMAGE CIRCLE DIAMETER: 4.5 mm (for 1/2" format sensor) (3.1 mm for 1/3")
EFFECTIVE FOCAL LENGTH: 0.7 mm (SCL with merged central image = 0.9 mm)
APERTURE RANGE: f/5.6 TO f/22 (SC5=f/8-22) (Either is 1 f/stop faster for 1/3")
PRIMARY REFLECTOR DIAMETER: 5-6 cm
FOCUSING: WITH REAR LOCK RING
MOUNTING: C MOUNT, CS MOUNT, CUSTOM
FILTER SIZE: GEL FILTERS
DIMENSIONS: 6 cm DIA, 7 cm LONG (SC5)
(35 mm & OTHER STILL PHOTO VERSIONS = ABOUT TWICE THIS SIZE)

SC5
(PICTORAL VIEW - PRIMARY REFLECTOR SURFACE SHOWN AS IT APPEARS THROUGH THE SOLID OPTIC)

FOCAL PLANE
0° 0° 180° 340°
AXIAL

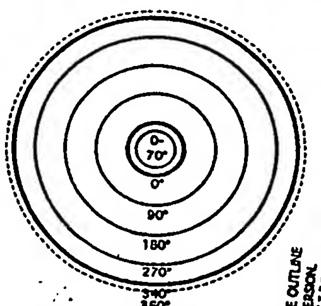
OPTIONAL ACCESSORIES:
* C-MOUNTS W/ OTHER FORMAT OPTICS
* CLEAR PLASTIC STORAGE AND SET UP TUBE. (CAN BE LEFT ON WHILE COMPOSING, REMOVED FOR USE)
* ADJUSTABLE SOLAR OCCULTING SPHERE

SMALL (~15%) CONCAVE CLEAR AREA IN CENTER OF SECONDARY REFLECTOR ACTS AS CENTRAL WIDE ANGLE LENS. UNIT CAN INSTEAD BE MADE SO PART OF SOLID OPTIC BORDERING OUTSIDE OF SECONDARY OBSTRUCTION IS NORMAL TO LIGHT ENTERING THE OPTIC, AND THE CENTRAL CONCAVE CLEAR SPOT CAN BE MADE SLIGHTLY LARGER. THIS WILL OBSTRUCT THE CENTRAL ~60-70° OF REFLECTOR COVERAGE, BUT THE OUTER LIMITS OF COVERAGE FROM THE CLEAR CENTRAL CONCAVE SPOT WILL FILL IN THIS AREA AND MERGE WITH IMAGE AROUND IT, PRODUCING CONTINUOUS COVERAGE WITHOUT ANY VISIBLE OBSTRUCTION AT ALL. A NEUTRAL DENSITY FILTER AND/OR A SMALL NEGATIVE OR OTHER LENS CAN BE IN FRONT OF CENTER OF SOLID OPTIC TO MODIFY CENTRAL IMAGE BRIGHTNESS, SCALE, LOCATION, COVERAGE, AND/OR PROJECTION. LENS COULD ALSO REPLACE CONCAVE SPOT.



SCL6

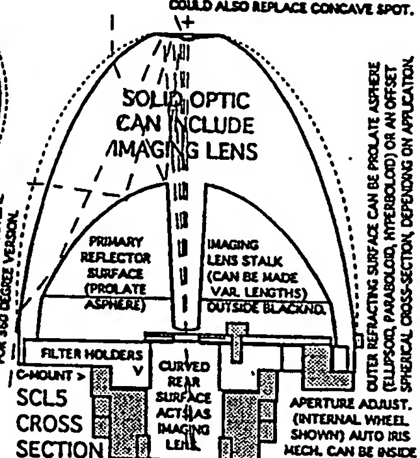
FOCAL PLANE
340° 180° 0° 0°
AXIAL



ANGULAR COVERAGE
(If redundant central coverage)
Merged central coverage = simple 0 to 340 or 360° continuous coverage.

KNURLED GRIP COLLAR
OPTIONAL APERTURE ADJUST. (f/5.6 TO f/22)
FOCUS ADJUSTMENT
C or CS MOUNT

DASHED LINE = ONE OUTLINE FOR 360 DEGREE VERSION.



OUTER REFRACTING SURFACE CAN BE PROLATE ASPHERE (ELLIPSOID, PARABOLOID, HYPERBOLOID) OR AN OFFSET SPHERICAL CROSS-SECTION, DEPENDING ON APPLICATION.

SCL5 CROSS SECTION

APERTURE ADJUST. (INTERNAL WHEEL SHOWN) AUTO IRIS MECH. CAN BE INSIDE

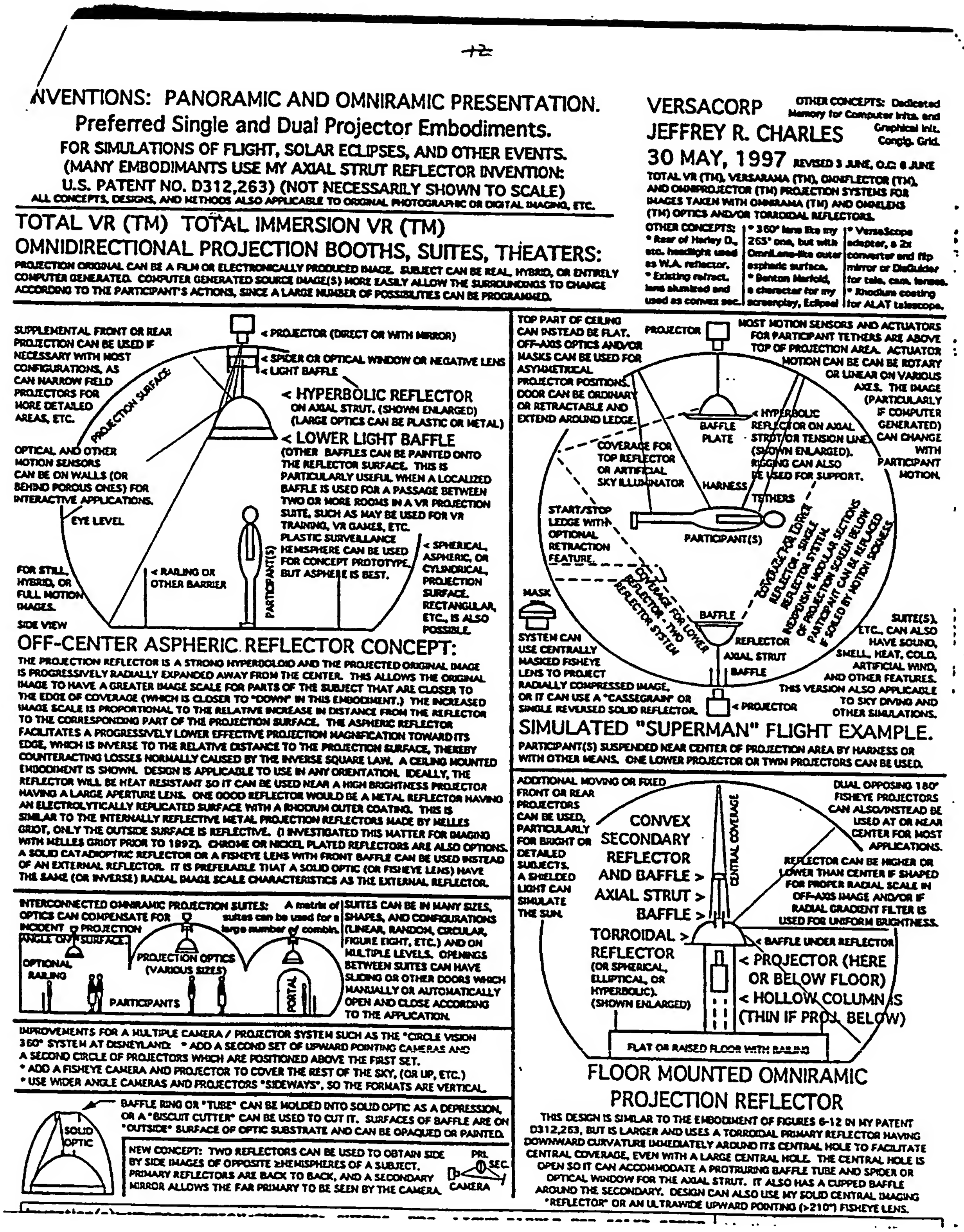
C-MOUNT CELL WITH FOCUS ADJUSTMENT. (VARIOUS LENGTHS CAN BE USED)

0° 0° 180° 340°+
AXIAL

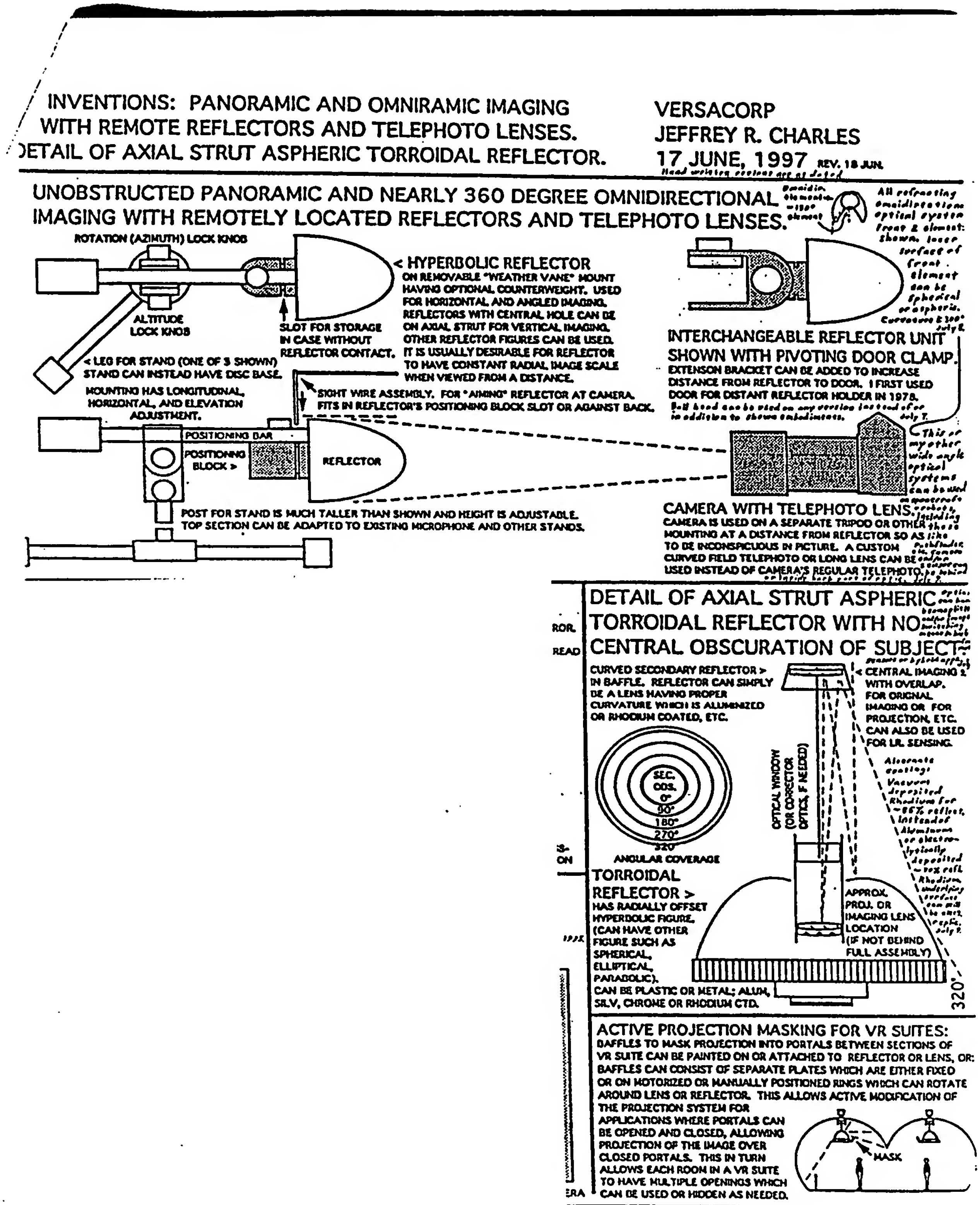
UNITS FOR FORMATS SMALLER THAN 1/2 INCH CAN HAVE FASTER f/RATIOS. GIVEN SIZE UNIT CAN HAVE FASTER f/RATIO IF RELATIVE SIZE OF CENTRAL OBSCURATION IMAGE IS LARGER. FULL FRAME COVERAGE IS POSSIBLE BY USING REAR OPTICS DESIGNED FOR LARGER FORMAT. AFOCAL OR OTHER RELAY LENS CAN BE USED TO ADAPT ANY MODEL TO A FIXED LENS CAMERA. SINGLE PIECE "OMNIOPTICS" CAN ALSO BE MADE FOR AFOCAL USE.

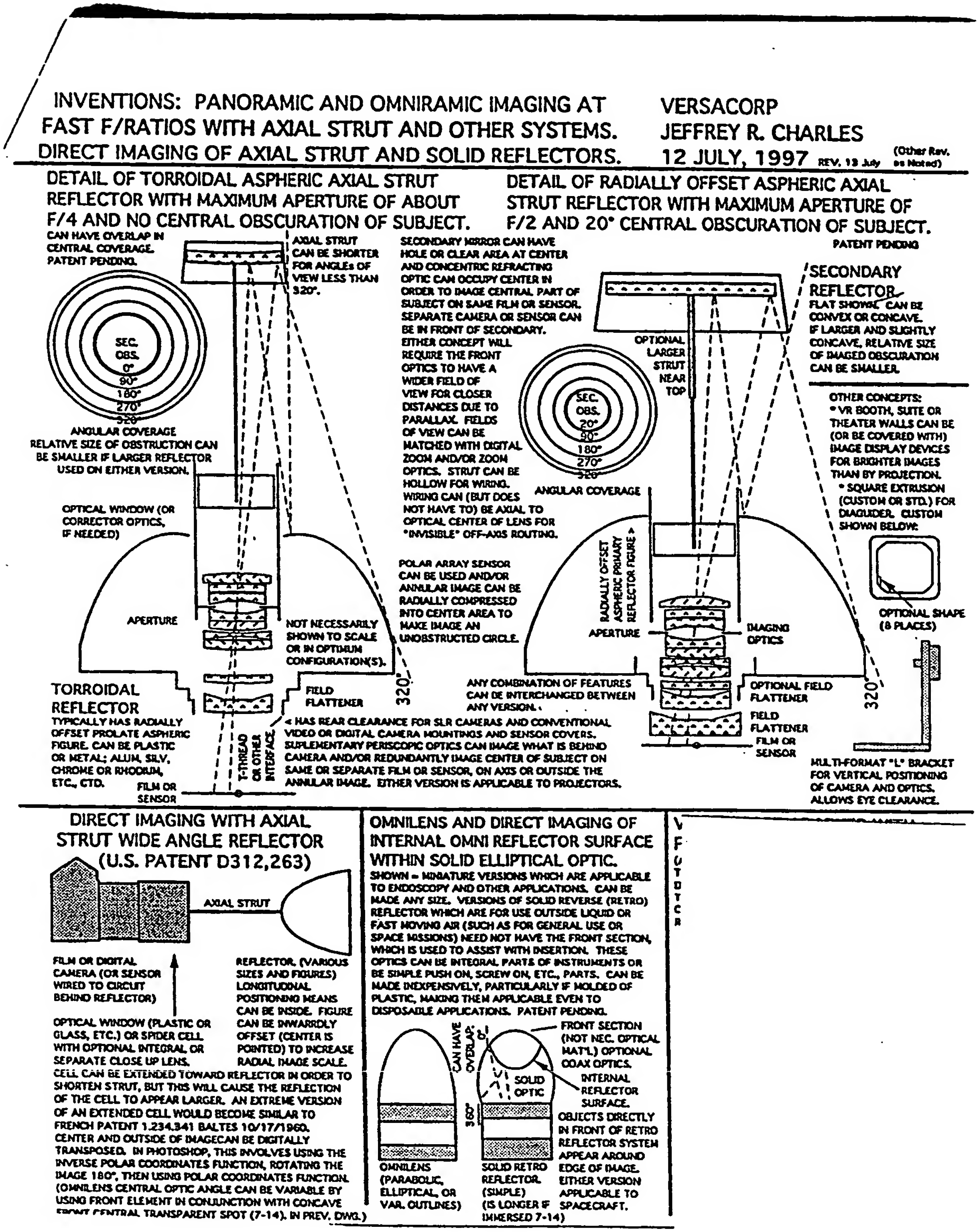
ADDITIONAL IMAGING OPTICS CAN FIT OVER A SHORTER MOLDED INTERNAL IMAGING LENS STALK AND/OR BE INCORPORATED INTO C-MOUNT CELL. OTHER OPTICS CAN BE USED INSTEAD OF STALK. ALL MODELS (INCLUDING THOSE FOR SURVEILLANCE, GUIDANCE, FILM CAMERAS, ETC.) CAN BE MADE TO HAVE ANY COMBINATION OF SHOWN FEATURES.

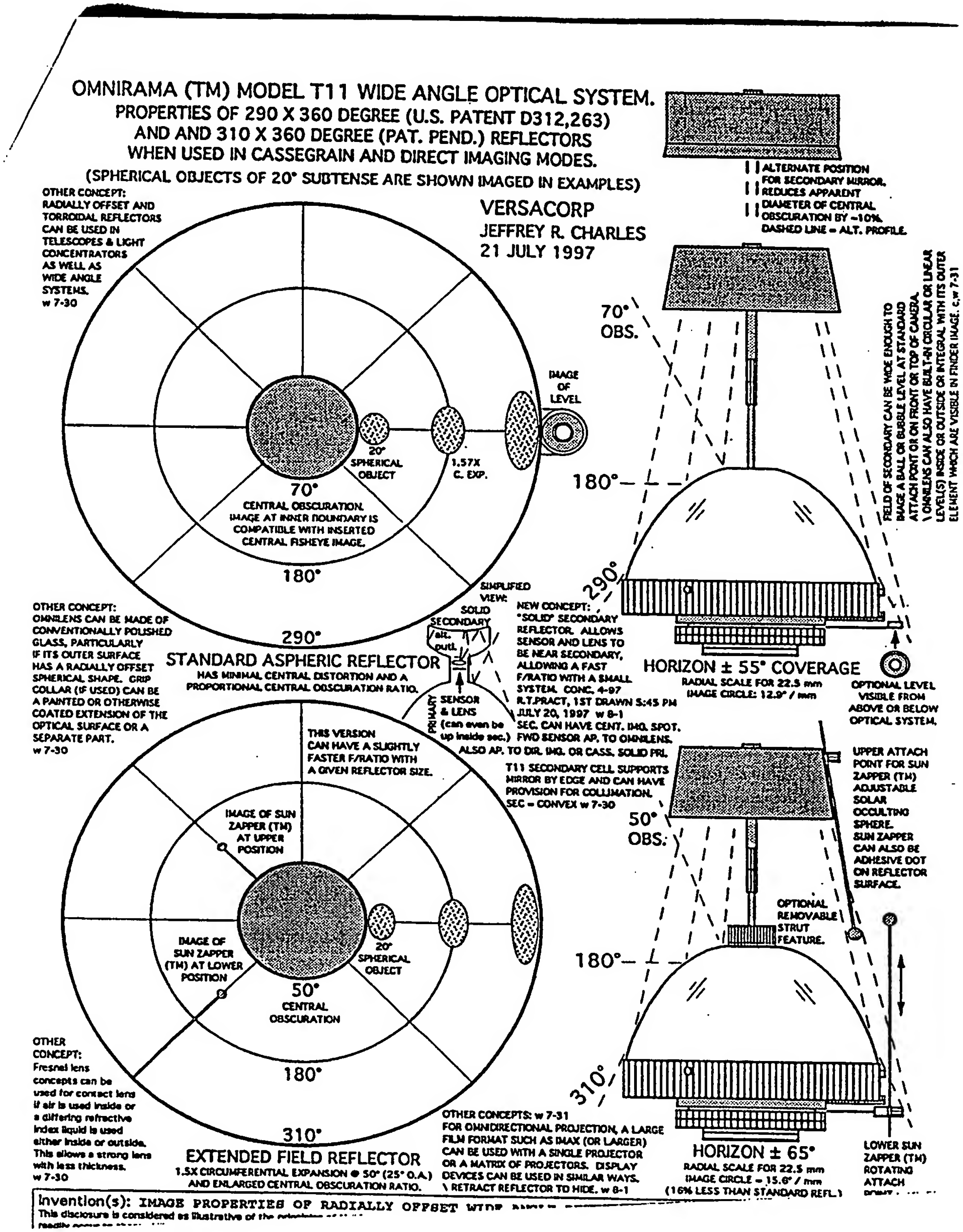
Entire product can be made of plastic if desired.



-12-
INVENTIONS: PANORAMIC AND OMNIRAMIC PRESENTATION.
Preferred Single and Dual Projector Embodiments.
FOR SIMULATIONS OF FLIGHT, SOLAR ECLIPSES, AND OTHER EVENTS.
(MANY EMBODIMANTS USE MY AXIAL STRUT REFLECTOR INVENTION:
U.S. PATENT NO. D312,263) (NOT NECESSARILY SHOWN TO SCALE)
ALL CONCEPTS, DESIGNS, AND METHODS ALSO APPLICABLE TO ORIGINAL PHOTOGRAPHIC OR DIGITAL IMAGING, ETC.
VERSACORP
JEFFREY R. CHARLES
30 MAY, 1997 REVISED 3 JUNE, O.C. 6 JUNE
OTHER CONCEPTS: Dedicated Memory for Computer Info. and Graphical Int. Config. Grid.
TOTAL VR (TM), VERSARAMA (TM), OMNIFLECTOR (TM), AND OMNIPROJECTOR (TM) PROJECTION SYSTEMS FOR IMAGES TAKEN WITH OMNIRAMA (TM) AND OMNILENS (TM) OPTICS AND/OR TORROIDAL REFLECTORS.
TOTAL VR (TM) TOTAL IMMERSION VR (TM)
OMNIDIRECTIONAL PROJECTION BOOTHS, SUITES, THEATERS:
PROJECTION ORIGINAL CAN BE A FILM OR ELECTRONICALLY PRODUCED IMAGE. SUBJECT CAN BE REAL, HYBRID, OR ENTIRELY COMPUTER GENERATED. COMPUTER GENERATED SOURCE IMAGE(S) MORE EASILY ALLOW THE SURROUNDINGS TO CHANGE ACCORDING TO THE PARTICIPANT'S ACTIONS, SINCE A LARGE NUMBER OF POSSIBILITIES CAN BE PROGRAMMED.
SUPPLEMENTAL FRONT OR REAR PROJECTION CAN BE USED IF NECESSARY WITH MOST CONFIGURATIONS, AS CAN NARROW FIELD PROJECTORS FOR MORE DETAILED AREAS, ETC.
< PROJECTOR (DIRECT OR WITH MIRROR)
< SPIDER OR OPTICAL WINDOW OR NEGATIVE LENS
< LIGHT BAFFLE
PROJECTION SURFACE
< HYPERBOLIC REFLECTOR
ON AXIAL STRUT. (SHOWN ENLARGED) (LARGE OPTICS CAN BE PLASTIC OR METAL)
< LOWER LIGHT BAFFLE
(OTHER BAFFLES CAN BE PAINTED ONTO THE REFLECTOR SURFACE. THIS IS PARTICULARLY USEFUL WHEN A LOCALIZED BAFFLE IS USED FOR A PASSAGE BETWEEN TWO OR MORE ROOMS IN A VR PROJECTION SUITE, SUCH AS MAY BE USED FOR VR TRAINING, VR GAMES, ETC.
OPTICAL AND OTHER MOTION SENSORS CAN BE ON WALLS (OR BEHIND POROUS ONES) FOR INTERACTIVE APPLICATIONS.
EYE LEVEL
PLASTIC SURVEILLANCE HEMISPHERE CAN BE USED FOR CONCEPT PROTOTYPE, BUT ASPHERE IS BEST.
< SPHERICAL, ASPHERIC, OR CYLINDRICAL PROJECTION SURFACE. RECTANGULAR, ETC., IS ALSO POSSIBLE.
FOR STILL, HYBRID, OR FULL MOTION IMAGES.
< RAILING OR OTHER BARRIER
PARTICIPANT(S)
SIDE VIEW
OFF-CENTER ASPHERIC REFLECTOR CONCEPT:
THE PROJECTION REFLECTOR IS A STRONG HYPERBOLOID AND THE PROJECTED ORIGINAL IMAGE IS PROGRESSIVELY RADIALLY EXPANDED AWAY FROM THE CENTER. THIS ALLOWS THE ORIGINAL IMAGE TO HAVE A GREATER IMAGE SCALE FOR PARTS OF THE SUBJECT THAT ARE CLOSER TO THE EDGE OF COVERAGE (WHICH IS CLOSER TO "DOWN" IN THIS EMBODIMENT.) THE INCREASED IMAGE SCALE IS PROPORTIONAL TO THE RELATIVE INCREASE IN DISTANCE FROM THE REFLECTOR TO THE CORRESPONDING PART OF THE PROJECTION SURFACE. THE ASPHERIC REFLECTOR FACILITATES A PROGRESSIVELY LOWER EFFECTIVE PROJECTION MAGNIFICATION TOWARD ITS EDGE, WHICH IS INVERSE TO THE RELATIVE DISTANCE TO THE PROJECTION SURFACE, THEREBY COUNTERACTING LOSSES NORMALLY CAUSED BY THE INVERSE SQUARE LAW. A CEILING MOUNTED EMBODIMENT IS SHOWN. DESIGN IS APPLICABLE TO USE IN ANY ORIENTATION. IDEALLY, THE REFLECTOR WILL BE HEAT RESISTANT SO IT CAN BE USED NEAR A HIGH BRIGHTNESS PROJECTOR HAVING A LARGE APERTURE LENS. ONE GOOD REFLECTOR WOULD BE A METAL REFLECTOR HAVING AN ELECTROLYTICALLY REPLICATED SURFACE WITH A RHODIUM OUTER COATING. THIS IS SIMILAR TO THE INTERNALLY REFLECTIVE METAL PROJECTION REFLECTORS MADE BY MELLES GRIOT, ONLY THE OUTSIDE SURFACE IS REFLECTIVE. (I INVESTIGATED THIS MATTER FOR IMAGING WITH MELLES GRIOT PRIOR TO 1992). CHROME OR NICKEL PLATED REFLECTORS ARE ALSO OPTIONS. A SOLID CATADIOPTRIC REFLECTOR OR A FISHEYE LENS WITH FRONT BAFFLE CAN BE USED INSTEAD OF AN EXTERNAL REFLECTOR. IT IS PREFERABLE THAT A SOLID OPTIC (OR FISHEYE LENS) HAVE THE SAME (OR INVERSE) RADIAL IMAGE SCALE CHARACTERISTICS AS THE EXTERNAL REFLECTOR.
TOP PART OF CEILING CAN INSTEAD BE FLAT. OFF-AXIS OPTICS AND/OR MASKS CAN BE USED FOR ASYMMETRICAL PROJECTOR POSITIONS. DOOR CAN BE ORDINARY OR RETRACTABLE AND EXTEND AROUND LEDGE.
PROJECTOR
MOST MOTION SENSORS AND ACTUATORS FOR PARTICIPANT TETHERS ARE ABOVE TOP OF PROJECTION AREA. ACTUATOR MOTION CAN BE CAN BE ROTARY OR LINEAR ON VARIOUS AXES. THE IMAGE (PARTICULARLY IF COMPUTER GENERATED) CAN CHANGE WITH PARTICIPANT MOTION.
BAFFLE PLATE
< HYPERBOLIC REFLECTOR ON AXIAL STRUT/OR TENSION LINE (SHOWN ENLARGED). RIGGING CAN ALSO BE USED FOR SUPPORT.
COVERAGE FOR TOP REFLECTOR OR ARTIFICIAL SKY ILLUMINATOR
HARNESS
TETHERS
START/STOP LEDGE WITH OPTIONAL RETRACTION FEATURE.
PARTICIPANT(S)
COVERAGE FOR LOWER REFLECTOR - SINGLE REFLECTOR SYSTEM. INEXPENSIVE MODULAR SECTIONS OF PROJECTION SCREEN BELOW PARTICIPANT CAN BE REPLACED IF SOILED BY MOTION SICKNESS.
COVERAGE FOR LOWER REFLECTOR - TWO REFLECTOR SYSTEM
MASK
BAFFLE
REFLECTOR
AXIAL STRUT
BAFFLE
SYSTEM CAN USE CENTRALLY MASKED FISHEYE LENS TO PROJECT RADIALLY COMPRESSED IMAGE, OR IT CAN USE A "CASSEGRAIN" OR SINGLE REVERSED SOLID REFLECTOR.
< PROJECTOR
SUITE(S), ETC., CAN ALSO HAVE SOUND, SMELL, HEAT, COLD, ARTIFICIAL WIND, AND OTHER FEATURES. THIS VERSION ALSO APPLICABLE TO SKY DIVING AND OTHER SIMULATIONS.
SIMULATED "SUPERMAN" FLIGHT EXAMPLE.
PARTICIPANT(S) SUSPENDED NEAR CENTER OF PROJECTION AREA BY HARNESS OR WITH OTHER MEANS. ONE LOWER PROJECTOR OR TWIN PROJECTORS CAN BE USED.
INTERCONNECTED OMNIRAMIC PROJECTION SUITES: A matrix of suites can be used for a large number of combin. OPTICS CAN COMPENSATE FOR INCIDENT PROJECTION ANGLE ON SURFACE.
OPTIONAL RAILING
PROJECTION OPTICS (VARIOUS SIZES)
PARTICIPANTS
PORTAL
SUITES CAN BE IN MANY SIZES, SHAPES, AND CONFIGURATIONS (LINEAR, RANDOM, CIRCULAR, FIGURE EIGHT, ETC.) AND ON MULTIPLE LEVELS. OPENINGS BETWEEN SUITES CAN HAVE SLIDING OR OTHER DOORS WHICH MANUALLY OR AUTOMATICALLY OPEN AND CLOSE ACCORDING TO THE APPLICATION.
IMPROVEMENTS FOR A MULTIPLE CAMERA / PROJECTOR SYSTEM SUCH AS THE "CIRCLE VISION 360° SYSTEM AT DISNEYLAND: * ADD A SECOND SET OF UPWARD POINTING CAMERAS AND A SECOND CIRCLE OF PROJECTORS WHICH ARE POSITIONED ABOVE THE FIRST SET.
* ADD A FISHEYE CAMERA AND PROJECTOR TO COVER THE REST OF THE SKY, (OR UP, ETC.)
* USE WIDER ANGLE CAMERAS AND PROJECTORS "SIDEWAYS", SO THE FORMATS ARE VERTICAL.
BAFFLE RING OR "TUBE" CAN BE MOLDED INTO SOLID OPTIC AS A DEPRESSION, OR A "BISCUIT CUTTER" CAN BE USED TO CUT IT. SURFACES OF BAFFLE ARE ON "OUTSIDE" SURFACE OF OPTIC SUBSTRATE AND CAN BE OPAQUED OR PAINTED.
SOLID OPTIC
NEW CONCEPT: TWO REFLECTORS CAN BE USED TO OBTAIN SIDE BY SIDE IMAGES OF OPPOSITE ≥HEMISPHERES OF A SUBJECT. PRIMARY REFLECTORS ARE BACK TO BACK, AND A SECONDARY MIRROR ALLOWS THE FAR PRIMARY TO BE SEEN BY THE CAMERA.
PRI.
SEC.
CAMERA
ADDITIONAL MOVING OR FIXED FRONT OR REAR PROJECTORS CAN BE USED, PARTICULARLY FOR BRIGHT OR DETAILED SUBJECTS. A SHIELDED LIGHT CAN SIMULATE THE SUN.
CONVEX SECONDARY REFLECTOR AND BAFFLE >
AXIAL STRUT >
BAFFLE >
CENTRAL COVERAGE
DUAL OPPOSING 180° FISHEYE PROJECTORS CAN ALSO/INSTEAD BE USED AT OR NEAR CENTER FOR MOST APPLICATIONS.
REFLECTOR CAN BE HIGHER OR LOWER THAN CENTER IF SHAPED FOR PROPER RADIAL SCALE IN OFF-AXIS IMAGE AND/OR IF RADIAL GRADIENT FILTER IS USED FOR UNIFORM BRIGHTNESS.
TORROIDAL > REFLECTOR (OR SPHERICAL, ELLIPTICAL, OR HYPERBOLIC). (SHOWN ENLARGED)
< BAFFLE UNDER REFLECTOR
< PROJECTOR (HERE OR BELOW FLOOR)
< HOLLOW COLUMN AS (THIN IF PROJ. BELOW)
FLAT OR RAISED FLOOR WITH RAILING
FLOOR MOUNTED OMNIRAMIC PROJECTION REFLECTOR
THIS DESIGN IS SIMILAR TO THE EMBODIMENT OF FIGURES 6-12 IN MY PATENT D312,263, BUT IS LARGER AND USES A TORROIDAL PRIMARY REFLECTOR HAVING DOWNWARD CURVATURE IMMEDIATELY AROUND ITS CENTRAL HOLE TO FACILITATE CENTRAL COVERAGE, EVEN WITH A LARGE CENTRAL HOLE. THE CENTRAL HOLE IS OPEN SO IT CAN ACCOMMODATE A PROTRUDING BAFFLE TUBE AND SPIDER OR OPTICAL WINDOW FOR THE AXIAL STRUT. IT ALSO HAS A CUPPED BAFFLE AROUND THE SECONDARY. DESIGN CAN ALSO USE MY SOLID CENTRAL IMAGING "REFLECTOR" OR AN ULTRAWIDE UPWARD POINTING (>210°) FISHEYE LENS.


INVENTIONS: PANORAMIC AND OMNIRAMIC IMAGING
WITH REMOTE REFLECTORS AND TELEPHOTO LENSES.
DETAIL OF AXIAL STRUT ASPHERIC TORROIDAL REFLECTOR.
VERSACORP
JEFFREY R. CHARLES
17 JUNE, 1997 REV. 18 JUN.
UNOBSTRUCTED PANORAMIC AND NEARLY 360 DEGREE OMNIDIRECTIONAL
IMAGING WITH REMOTELY LOCATED REFLECTORS AND TELEPHOTO LENSES.
ROTATION (AZIMUTH) LOCK KNOB
ALTITUDE LOCK KNOB
< HYPERBOLIC REFLECTOR
ON REMOVABLE "WEATHER VANE" MOUNT HAVING OPTIONAL COUNTERWEIGHT. USED FOR HORIZONTAL AND ANGLED IMAGING. REFLECTORS WITH CENTRAL HOLE CAN BE ON AXIAL STRUT FOR VERTICAL IMAGING. OTHER REFLECTOR FIGURES CAN BE USED. IT IS USUALLY DESIRABLE FOR REFLECTOR TO HAVE CONSTANT RADIAL IMAGE SCALE WHEN VIEWED FROM A DISTANCE.
SLOT FOR STORAGE IN CASE WITHOUT REFLECTOR CONTACT.
< LEG FOR STAND (ONE OF 3 SHOWN) STAND CAN INSTEAD HAVE DISC BASE.
MOUNTING HAS LONGITUDINAL, HORIZONTAL, AND ELEVATION ADJUSTMENT.
SIGHT WIRE ASSEMBLY. FOR "AIMING" REFLECTOR AT CAMERA. FITS IN REFLECTOR'S POSITIONING BLOCK SLOT OR AGAINST BACK.
POSITIONING BAR
POSITIONING BLOCK >
REFLECTOR
POST FOR STAND IS MUCH TALLER THAN SHOWN AND HEIGHT IS ADJUSTABLE. TOP SECTION CAN BE ADAPTED TO EXISTING MICROPHONE AND OTHER STANDS.
INTERCHANGEABLE REFLECTOR UNIT SHOWN WITH PIVOTING DOOR CLAMP.
EXTENSION BRACKET CAN BE ADDED TO INCREASE DISTANCE FROM REFLECTOR TO DOOR. I FIRST USED DOOR FOR DISTANT REFLECTOR HOLDER IN 1978.
CAMERA WITH TELEPHOTO LENS.
CAMERA IS USED ON A SEPARATE TRIPOD OR OTHER MOUNTING AT A DISTANCE FROM REFLECTOR SO AS TO BE INCONSPICUOUS IN PICTURE. A CUSTOM CURVED FIELD TELEPHOTO OR LONG LENS CAN BE USED INSTEAD OF CAMERA'S REGULAR TELEPHOTO.
DETAIL OF AXIAL STRUT ASPHERIC TORROIDAL REFLECTOR WITH NO CENTRAL OBSCURATION OF SUBJECT
CURVED SECONDARY REFLECTOR > IN BAFFLE. REFLECTOR CAN SIMPLY BE A LENS HAVING PROPER CURVATURE WHICH IS ALUMINIZED OR RHODIUM COATED, ETC.
< CENTRAL IMAGING WITH OVERLAP. FOR ORIGINAL IMAGING OR FOR PROJECTION, ETC. CAN ALSO BE USED FOR I.R. SENSING.
OPTICAL WINDOW (OR CORRECTOR OPTICS, IF NEEDED)
SEC. OBS. 0° 90° 180° 270° 320°
ANGULAR COVERAGE
TORROIDAL REFLECTOR >
HAS RADIALLY OFFSET HYPERBOLIC FIGURE. (CAN HAVE OTHER FIGURE SUCH AS SPHERICAL, ELLIPTICAL, PARABOLIC). CAN BE PLASTIC OR METAL; ALUM, SILV, CHROME OR RHODIUM CTD.
APPROX. PROJ. OR IMAGING LENS LOCATION (IF NOT BEHIND FULL ASSEMBLY)
320°
ACTIVE PROJECTION MASKING FOR VR SUITES:
BAFFLES TO MASK PROJECTION INTO PORTALS BETWEEN SECTIONS OF VR SUITE CAN BE PAINTED ON OR ATTACHED TO REFLECTOR OR LENS, OR: BAFFLES CAN CONSIST OF SEPARATE PLATES WHICH ARE EITHER FIXED OR ON MOTORIZED OR MANUALLY POSITIONED RINGS WHICH CAN ROTATE AROUND LENS OR REFLECTOR. THIS ALLOWS ACTIVE MODIFICATION OF THE PROJECTION SYSTEM FOR APPLICATIONS WHERE PORTALS CAN BE OPENED AND CLOSED, ALLOWING PROJECTION OF THE IMAGE OVER CLOSED PORTALS. THIS IN TURN ALLOWS EACH ROOM IN A VR SUITE TO HAVE MULTIPLE OPENINGS WHICH CAN BE USED OR HIDDEN AS NEEDED.
MASK


INVENTIONS: PANORAMIC AND OMNIRAMIC IMAGING AT FAST F/RATIOS WITH AXIAL STRUT AND OTHER SYSTEMS. DIRECT IMAGING OF AXIAL STRUT AND SOLID REFLECTORS.
VERSACORP
JEFFREY R. CHARLES
12 JULY, 1997 REV. 13 July (Other Rev. as Noted)
DETAIL OF TORROIDAL ASPHERIC AXIAL STRUT REFLECTOR WITH MAXIMUM APERTURE OF ABOUT F/4 AND NO CENTRAL OBSCURATION OF SUBJECT.
CAN HAVE OVERLAP IN CENTRAL COVERAGE. PATENT PENDING.
AXIAL STRUT CAN BE SHORTER FOR ANGLES OF VIEW LESS THAN 320°.
SEC. OBS.
0°
90°
180°
270°
320°
ANGULAR COVERAGE
RELATIVE SIZE OF OBSTRUCTION CAN BE SMALLER IF LARGER REFLECTOR USED ON EITHER VERSION.
OPTICAL WINDOW (OR CORRECTOR OPTICS, IF NEEDED)
APERTURE
NOT NECESSARILY SHOWN TO SCALE OR IN OPTIMUM CONFIGURATION(S).
TORROIDAL REFLECTOR
TYPICALLY HAS RADIALLY OFFSET PROLATE ASPHERIC FIGURE. CAN BE PLASTIC OR METAL; ALUM, SILV, CHROME OR RHODIUM, ETC., CTD.
FIELD FLATTENER
320°
T-THREAD OR OTHER INTERFACE
FILM OR SENSOR
SECONDARY MIRROR CAN HAVE HOLE OR CLEAR AREA AT CENTER AND CONCENTRIC REFRACTING OPTIC CAN OCCUPY CENTER IN ORDER TO IMAGE CENTRAL PART OF SUBJECT ON SAME FILM OR SENSOR. SEPARATE CAMERA OR SENSOR CAN BE IN FRONT OF SECONDARY. EITHER CONCEPT WILL REQUIRE THE FRONT OPTICS TO HAVE A WIDER FIELD OF VIEW FOR CLOSER DISTANCES DUE TO PARALLAX. FIELDS OF VIEW CAN BE MATCHED WITH DIGITAL ZOOM AND/OR ZOOM OPTICS. STRUT CAN BE HOLLOW FOR WIRING. WIRING CAN (BUT DOES NOT HAVE TO) BE AXIAL TO OPTICAL CENTER OF LENS FOR "INVISIBLE" OFF-AXIS ROUTING.
POLAR ARRAY SENSOR CAN BE USED AND/OR ANNULAR IMAGE CAN BE RADIALLY COMPRESSED INTO CENTER AREA TO MAKE IMAGE AN UNOBSTRUCTED CIRCLE.
ANY COMBINATION OF FEATURES CAN BE INTERCHANGED BETWEEN ANY VERSION.
< HAS REAR CLEARANCE FOR SLR CAMERAS AND CONVENTIONAL VIDEO OR DIGITAL CAMERA MOUNTINGS AND SENSOR COVERS. SUPPLEMENTARY PERISCOPIC OPTICS CAN IMAGE WHAT IS BEHIND CAMERA AND/OR REDUNDANTLY IMAGE CENTER OF SUBJECT ON SAME OR SEPARATE FILM OR SENSOR, ON AXIS OR OUTSIDE THE ANNULAR IMAGE. EITHER VERSION IS APPLICABLE TO PROJECTORS.
DETAIL OF RADIALLY OFFSET ASPHERIC AXIAL STRUT REFLECTOR WITH MAXIMUM APERTURE OF F/2 AND 20° CENTRAL OBSCURATION OF SUBJECT.
PATENT PENDING
SECONDARY REFLECTOR
FLAT SHOWN. CAN BE CONVEX OR CONCAVE. IF LARGER AND SLIGHTLY CONCAVE, RELATIVE SIZE OF IMAGED OBSCURATION CAN BE SMALLER.
OPTIONAL LARGER STRUT NEAR TOP
SEC. OBS.
20°
90°
180°
270°
320°
ANGULAR COVERAGE
OTHER CONCEPTS:
• VR BOOTH, SUITE OR THEATER WALLS CAN BE (OR BE COVERED WITH) IMAGE DISPLAY DEVICES FOR BRIGHTER IMAGES THAN BY PROJECTION.
• SQUARE EXTRUSION (CUSTOM OR STD.) FOR DIAGUIDER. CUSTOM SHOWN BELOW:
OPTIONAL SHAPE (8 PLACES)
RADIALLY OFFSET ASPHERIC PRIMARY REFLECTOR FIGURE
APERTURE
IMAGING OPTICS
OPTIONAL FIELD FLATTENER
FIELD FLATTENER
FILM OR SENSOR
320°
MULTI-FORMAT "L" BRACKET FOR VERTICAL POSITIONING OF CAMERA AND OPTICS. ALLOWS EYE CLEARANCE.
DIRECT IMAGING WITH AXIAL STRUT WIDE ANGLE REFLECTOR (U.S. PATENT D312,263)
AXIAL STRUT
FILM OR DIGITAL CAMERA (OR SENSOR WIRED TO CIRCUIT BEHIND REFLECTOR)
REFLECTOR (VARIOUS SIZES AND FIGURES) LONGITUDINAL POSITIONING MEANS CAN BE INSIDE. FIGURE CAN BE INWARRDLY OFFSET (CENTER IS POINTED) TO INCREASE RADIAL IMAGE SCALE.
OPTICAL WINDOW (PLASTIC OR GLASS, ETC.) OR SPIDER CELL WITH OPTIONAL INTEGRAL OR SEPARATE CLOSE UP LENS. CELL CAN BE EXTENDED TOWARD REFLECTOR IN ORDER TO SHORTEN STRUT, BUT THIS WILL CAUSE THE REFLECTION OF THE CELL TO APPEAR LARGER. AN EXTREME VERSION OF AN EXTENDED CELL WOULD BECOME SIMILAR TO FRENCH PATENT 1.234.341 BALTES 10/17/1960. CENTER AND OUTSIDE OF IMAGECAN BE DIGITALLY TRANSPOSED. IN PHOTOSHOP, THIS INVOLVES USING THE INVERSE POLAR COORDINATES FUNCTION, ROTATING THE IMAGE 180°, THEN USING POLAR COORDINATES FUNCTION. (OMNILENS CENTRAL OPTIC ANGLE CAN BE VARIABLE BY USING FRONT ELEMENT IN CONJUNCTION WITH CONCAVE FRONT CENTRAL TRANSPARENT SPOT (7-14). IN PREV. DWG.)
OMNILENS AND DIRECT IMAGING OF INTERNAL OMNI REFLECTOR SURFACE WITHIN SOLID ELLIPTICAL OPTIC.
SHOWN = MINIATURE VERSIONS WHICH ARE APPLICABLE TO ENDOSCOPY AND OTHER APPLICATIONS. CAN BE MADE ANY SIZE. VERSIONS OF SOLID REVERSE (RETRO) REFLECTOR WHICH ARE FOR USE OUTSIDE LIQUID OR FAST MOVING AIR (SUCH AS FOR GENERAL USE OR SPACE MISSIONS) NEED NOT HAVE THE FRONT SECTION, WHICH IS USED TO ASSIST WITH INSERTION. THESE OPTICS CAN BE INTEGRAL PARTS OF INSTRUMENTS OR BE SIMPLE PUSH ON, SCREW ON, ETC., PARTS. CAN BE MADE INEXPENSIVELY, PARTICULARLY IF MOLDED OF PLASTIC, MAKING THEM APPLICABLE EVEN TO DISPOSABLE APPLICATIONS. PATENT PENDING.
CAN HAVE OVERLAP
FRONT SECTION (NOT NEC. OPTICAL MAT'L) OPTIONAL COAX OPTICS.
SOLID OPTIC
INTERNAL REFLECTOR SURFACE.
360°
OBJECTS DIRECTLY IN FRONT OF RETRO REFLECTOR SYSTEM APPEAR AROUND EDGE OF IMAGE. EITHER VERSION APPLICABLE TO SPACECRAFT.
OMNILENS (PARABOLIC, ELLIPTICAL, OR VAR. OUTLINES)
SOLID RETRO REFLECTOR (SIMPLE) (IS LONGER IF IMMERSED 7-14)



OMNIRAMA (TM) MODEL T11 WIDE ANGLE OPTICAL SYSTEM.
PROPERTIES OF 290 X 360 DEGREE (U.S. PATENT D312,263)
AND AND 310 X 360 DEGREE (PAT. PEND.) REFLECTORS
WHEN USED IN CASSEGRAIN AND DIRECT IMAGING MODES.
(SPHERICAL OBJECTS OF 20° SUBTENSE ARE SHOWN IMAGED IN EXAMPLES)
VERSACORP
JEFFREY R. CHARLES
21 JULY 1997
OTHER CONCEPT: RADIALLY OFFSET AND TORROIDAL REFLECTORS CAN BE USED IN TELESCOPES & LIGHT CONCENTRATORS AS WELL AS WIDE ANGLE SYSTEMS. w 7-30
ALTERNATE POSITION FOR SECONDARY MIRROR. REDUCES APPARENT DIAMETER OF CENTRAL OBSCURATION BY ~10%. DASHED LINE = ALT. PROFILE.
IMAGE OF LEVEL
20° SPHERICAL OBJECT
1.57X C. EXP.
70°
CENTRAL OBSCURATION. IMAGE AT INNER BOUNDARY IS COMPATIBLE WITH INSERTED CENTRAL FISHEYE IMAGE.
180°
290°
STANDARD ASPHERIC REFLECTOR
HAS MINIMAL CENTRAL DISTORTION AND A PROPORTIONAL CENTRAL OBSCURATION RATIO.
70° OBS.
180°
290°
FIELD OF SECONDARY CAN BE WIDE ENOUGH TO IMAGE A BALL OR BUBBLE LEVEL AT STANDARD ATTACH POINT OR ON FRONT OR TOP OF CAMERA. \ OMNILENS CAN ALSO HAVE BUILT-IN CIRCULAR OR LINEAR LEVEL(S) INSIDE OR OUTSIDE OR INTEGRAL WITH ITS OUTER ELEMENT WHICH ARE VISIBLE IN FINDER IMAGE. c w 7-31
HORIZON ± 55° COVERAGE
RADIAL SCALE FOR 22.5 mm IMAGE CIRCLE: 12.9° / mm
OPTIONAL LEVEL VISIBLE FROM ABOVE OR BELOW OPTICAL SYSTEM.
OTHER CONCEPT: OMNILENS CAN BE MADE OF CONVENTIONALLY POLISHED GLASS, PARTICULARLY IF ITS OUTER SURFACE HAS A RADIALLY OFFSET SPHERICAL SHAPE. GRIP COLLAR (IF USED) CAN BE A PAINTED OR OTHERWISE COATED EXTENSION OF THE OPTICAL SURFACE OR A SEPARATE PART. w 7-30
SIMPLIFIED VIEW: SOLID SECONDARY
alt. putl.
PRIMARY
SENSOR & LENS (can even be up inside sec.)
NEW CONCEPT: "SOLID" SECONDARY REFLECTOR. ALLOWS SENSOR AND LENS TO BE NEAR SECONDARY, ALLOWING A FAST F/RATIO WITH A SMALL SYSTEM. CONC. 4-97 R.T.PRACT, 1ST DRAWN 5:45 PM JULY 20, 1997 w 8-1 SEC. CAN HAVE CENT. IMG. SPOT. FWD SENSOR AP. TO OMNILENS. ALSO AP. TO DIR. IMG. OR CASS. SOLID PRI.
THIS VERSION CAN HAVE A SLIGHTLY FASTER F/RATIO WITH A GIVEN REFLECTOR SIZE.
T11 SECONDARY CELL SUPPORTS MIRROR BY EDGE AND CAN HAVE PROVISION FOR COLLIMATION. SEC = CONVEX w 7-30
UPPER ATTACH POINT FOR SUN ZAPPER (TM) ADJUSTABLE SOLAR OCCULTING SPHERE. SUN ZAPPER CAN ALSO BE ADHESIVE DOT ON REFLECTOR SURFACE.
IMAGE OF SUN ZAPPER (TM) AT UPPER POSITION
IMAGE OF SUN ZAPPER (TM) AT LOWER POSITION
20° SPHERICAL OBJECT
50° CENTRAL OBSCURATION
180°
310°
50° OBS.
OPTIONAL REMOVABLE STRUT FEATURE.
180°
310°
OTHER CONCEPT: Fresnel lens concepts can be used for contact lens if air is used inside or a differing refractive index liquid is used either inside or outside. This allows a strong lens with less thickness. w 7-30
EXTENDED FIELD REFLECTOR
1.5X CIRCUMFERENTIAL EXPANSION @ 50° (25° O.A.) AND ENLARGED CENTRAL OBSCURATION RATIO.
OTHER CONCEPTS: w 7-31 FOR OMNIDIRECTIONAL PROJECTION, A LARGE FILM FORMAT SUCH AS IMAX (OR LARGER) CAN BE USED WITH A SINGLE PROJECTOR OR A MATRIX OF PROJECTORS. DISPLAY DEVICES CAN BE USED IN SIMILAR WAYS. \ RETRACT REFLECTOR TO HIDE. w 8-1
HORIZON ± 65°
RADIAL SCALE FOR 22.5 mm IMAGE CIRCLE = 15.6° / mm (16% LESS THAN STANDARD REFL.)
LOWER SUN ZAPPER (TM) ROTATING ATTACH
Invention(s): IMAGE PROPERTIES OF RADIALLY OFFSET
This disclosure is considered as illustrative of the

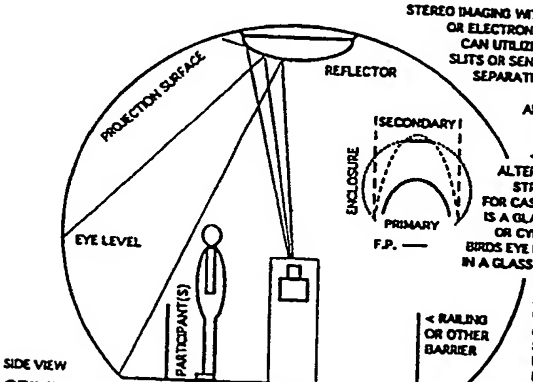
INVENTIONS: PANORAMIC AND OMNIRAMIC PRESENTATION.
Preferred Single and Dual Projector Embodiments.
FOR SIMULATIONS OF FLIGHT, SOLAR ECLIPSES, AND OTHER EVENTS.
(MANY EMBODIMENTS USE MY AXIAL STRUT REFLECTOR INVENTION:
U.S. PATENT NO. D312,263) (NOT NECESSARILY SHOWN TO SCALE)
ALL CONCEPTS, DESIGNS, AND METHODS ALSO APPLICABLE TO ORIGINAL PHOTOGRAPHIC OR DIGITAL IMAGING, ETC.

VERSACORP
JEFFREY R. CHARLES
8 AUG, 1997 LATE A.M. REVISED AS NOTED.

TOTAL VR (TM), TOTAL IMMERSION VR (TM) OMNIFLECTOR (TM), OMNIJECTOR (TM), OMNIPROJECTOR (TM) PROJECTION SYSTEMS FOR IMAGES MADE WITH OMNIRAMA (TM) AND OMNILENS (TM) OPTICS AND/OR TORROIDAL REFLECTORS.
OTHER CONCEPTS:
* Use of conventional Barlow lens like that for astronomical telescope as a field flattener for omnidirectional (particularly reflective) optical systems.
* Axial strut and secondary (or camera) with baffle retract inside unit to protect primary. Retracted secondary baffle can be made so it will completely cover the primary. Aug. 10.
* Two tandem reflectors (particularly in a solid optic) can provide fully redundant omnidirectional coverage for stereo imaging, ranging, projection, etc. All des. can utilize conv., torroidal, etc., refl. See top corner figures below. Aug. 10.

TOTAL VR (TM) TOTAL IMMERSION VR (TM) OMNIDIRECTIONAL PROJECTION SIMULATORS, GAMES, BOOTHS, SUITES, THEATERS:

PROJECTION ORIGINAL CAN BE A FILM OR ELECTRONICALLY PRODUCED IMAGE. SUBJECT CAN BE REAL, HYBRID, OR ENTIRELY COMPUTER GENERATED. COMPUTER GENERATED SOURCE IMAGE(S) MORE EASILY ALLOW THE SURROUNDINGS TO CHANGE ACCORDING TO PARTICIPANT'S ACTIONS, SINCE A LARGE NUMBER OF POSSIBILITIES CAN BE PROGRAMMED. THIS IS DESIRABLE FOR VIRTUAL REALITY SIMULATIONS, GAMES, ETC., INCLUDING "FULL CANOPY" FLIGHT SIMULATION. THESE CONCEPTS CAN ALSO BE USED TO PROJECT ON THE WALL BELOW A CONVENTIONAL PLANETARIUM DOME, ETC.



OTHER CONCEPT: STEREO IMAGING WITH PANORAMIC FILM OR ELECTRONIC IMAGING CAMERA CAN UTILIZE TWIN LENSES AND SLITS OR SENSORS IN WHICH THE SEPARATION IS ADJUSTABLE. THIS ALLOWS EASY ADJUSTMENT OF THE DEGREE OF STEREO EFFECT. AUG. 9

< OTHER CONCEPT: ALTERNATIVES TO AXIAL STRUT, PARTICULARLY FOR CASSEGRAIN SYSTEMS, IS A GLASS DOME, BUBBLE, OR CYLINDER. SHRATONE BIRDS EYE IS ONE REFLECTOR IN A GLASS CYLINDER. AUG. 9

CEILING MOUNTED ASPHERIC REFLECTOR CONCEPT.

APPLICABLE TO SINGLE AND MULTIPLE MIRROR SYSTEMS.

SYSTEMS CAN BE USED AT ANY ORIENTATION, INCLUDING UPSIDE DOWN FROM THAT SHOWN. THESE WIDE ANGLE REFLECTOR SYSTEMS CAN BE INTEGRATED INTO A CUSTOM PROJECTOR ASSEMBLY OR THEY CAN BE FIXTURES THAT ARE USED WITH EXISTING PROJECTORS INCLUDING FILM PROJECTORS AND ELECTRONIC MEDIA PROJECTORS SUCH AS THE SINGLE LENS BARCO (R) COLOR LCD PROJECTOR. MULTIPLE LENS PROJECTORS CAN BE USED IF THE IMAGES ARE EITHER COMBINED BEFORE REACHING THE PRIMARY REFLECTOR OR IF THEY ARE BROUGHT TO A COMMON FOCUS AND CONVERGENCE AT THE VIRTUAL IMAGE "SURFACE" OF THE OPTICAL SYSTEM. WHERE APPROPRIATE, THE REFLECTOR(S) CAN BE CENTRALLY OR OTHERWISE MASKED.

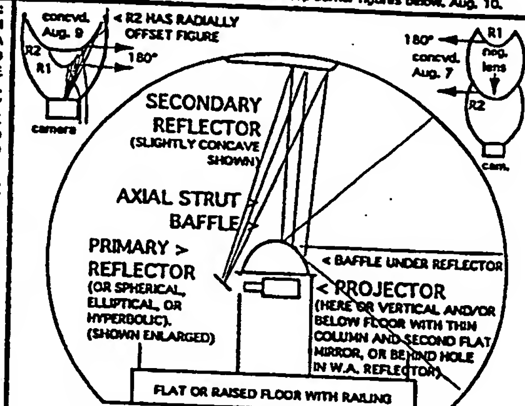
IF THE CEILING MOUNTED REFLECTOR IS A PRIMARY REFLECTOR USED WITH A FLOOR MOUNTED PROJECTOR, IT WILL TYPICALLY BE A CONVEX OBLATE ELLIPSOID. AN APPROPRIATE RADIALLY OFFSET REFLECTOR FIGURE (HAVING AN INWARD OFFSET WHICH RESULTS IN A POINTED CENTER) CAN BE USED TO ALLOW THE USE OF AN ORIGINAL PROJECTED IMAGE WHICH HAS LITTLE OR NO BLANK AREA IN THE CENTER, RESULTING IN A LARGER RADIAL IMAGE SCALE. THIS CENTRAL AREA WOULD BE EQUIVALENT TO THE PART OF THE FLOOR COVERED BY A CONVENTIONAL REFLECTOR THAT WOULD BE SUBJECT TO SHADOWING BY THE PARTICIPANTS. THE ORIGINAL PROJECTED IMAGE WILL HAVE THE GROUND (OR "DOWN") AT THE CENTER OF THE IMAGE AND THE SKY AROUND THE OUTSIDE. (BUT AN APPROPRIATE CONCAVE TORROID REFLECTOR CAN REVERSE THE SKY-GROUND RELATIONSHIP, ALLOWING THE ORIGINAL IMAGE TO HAVE THE SKY IN THE CENTER).

WHERE THERE ARE TWO (OR MORE) CEILING MOUNTED MIRRORS (I.E. A CASSEGRAIN SYSTEM, WITH EITHER THE SMALL OR THE LARGE MIRROR SERVING AS THE PRIMARY) ARE USED WITH A FLOOR MOUNTED PROJECTOR, THE ORIGINAL IMAGE CAN HAVE THE SKY IN THE CENTER, ALLOWING OTHER CHARACTERISTICS OF THE SYSTEM TO BE LIKE OR SIMILAR THOSE SHOWN AND DESCRIBED IN MY "OFF-CENTER ASPHERIC REFLECTOR" CONCEPT ON MY 30 MAY, 1997 DOCUMENT. ONE OR MORE OF THE REFLECTORS CAN CAN BE SUPPORTED BY AN AXIAL STRUT OR OTHER MEANS.

BUT AND PRIMARY REFLECTOR, THE PROJECTOR CAN EITHER BE BEHIND (UNDER) THE PRIMARY REFLECTOR AND PROJECT THROUGH A HOLE IN ITS CENTER OR IT CAN BE OFF-AXIS (PREFERRABLY AS CLOSE TO THE PRIMARY REFLECTOR OPTICAL AXIS AS POSSIBLE) AND PROJECT THE IMAGE TOWARD THE SECONDARY REFLECTOR FROM BESIDE THE PRIMARY. THIS OFF-AXIS PROJECTOR SYSTEM WILL ALSO ALLOW THE PROJECTOR TO BE POSITIONED HORIZONTALLY BEHIND THE PRIMARY REFLECTOR AND PROJECT THE IMAGE INTO A MIRROR IMMEDIATELY BESIDE THE PRIMARY WHICH IN TURN DIRECTS THE PROJECTION TOWARD THE SECONDARY REFLECTOR.

THE SECONDARY REFLECTOR CAN BE FLAT, CONVEX, OR CONCAVE, WITH A SLIGHTLY CONCAVE ONE FACILITATING THE USE OF A PROJECTOR LENS HAVING RELATIVELY CONVENTIONAL ANGLE OF VIEW.

A CEILING MOUNTED PROJECTOR AND MASKED OR UNMASKED 180 DEGREE FISHEYE LENS (POSSIBLY EVEN AN EXISTING ONE) CAN ALSO BE USED.

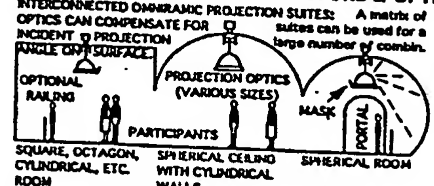


FLOOR MOUNTED PROJECTOR AND OMNIRAMIC PRIMARY PROJECTION REFLECTOR FOR USE WITH CEILING MOUNTED SECONDARY.

SEPARATED OR MERGED OPTICAL CLUSTERS CAN BE USED FOR 3D IMAGING AND PROJECTION WITH OPTICAL STEREO SEPATATION PERPENDICULAR TO THE OPTICAL AXIS. > MERGED FOUR REFLECTOR CLUSTER SHOWN. C&D AUG. 11.

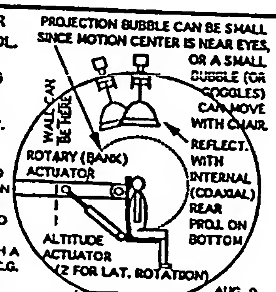
ANY COMBINATION OF ROOM SHAPES CAN BE USED WITH ANY COMBINATION OF PROJECTORS & OPTICS:

INTERCONNECTED OMNIRAMIC PROJECTION SUITES: A matrix of suites can be used for a large number of combin.



FLIGHT OR PROCESS SIMULATOR AND/OR MONITOR AND CONTROL.

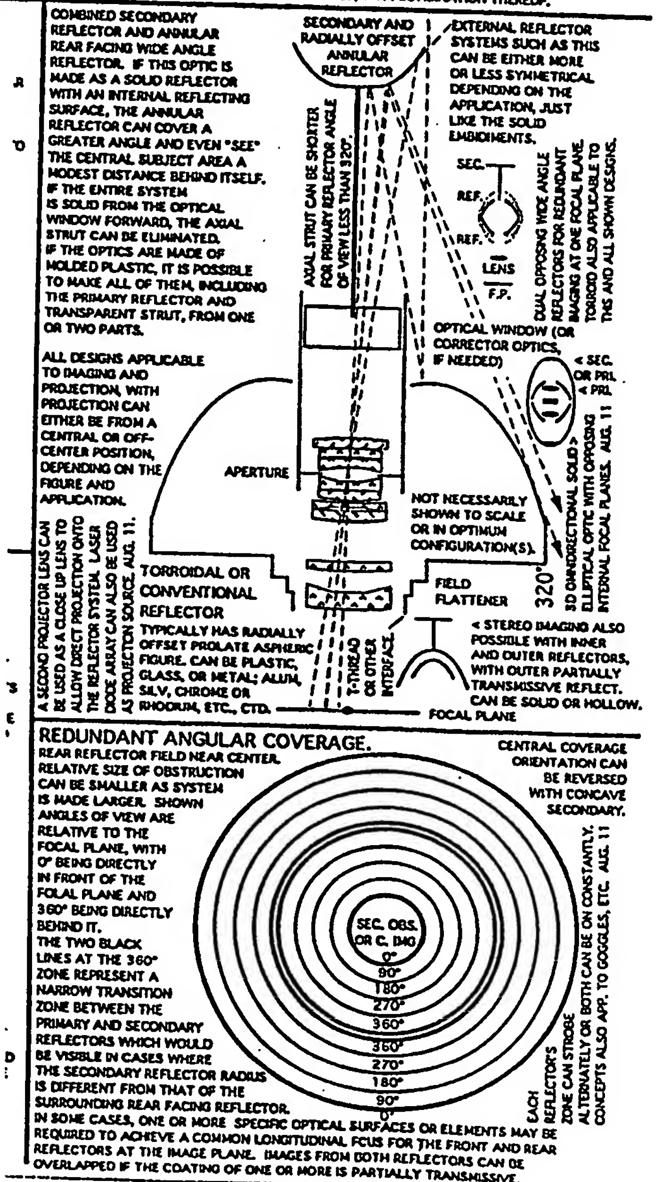
PILOT(S) OR CONTROLLER(S) CAN STAND OR BE SEATED WITH HEAD(S) NEAR CENTER OF PROJECTION AREA. CAN HAVE FULL COCKPIT/CONTROL AREA VIEW OR FULL "CANOPY" VIEW. IDEAL FOR ROBOTICS OR UAVs. PROJECTOR CAN BE AT TOP WHERE SHOWN OR UP TO ABOUT 30° BEHIND HEAD OF PILOT/CONTROLLER. MOTION CONTROL (WHERE NEEDED) EFFECTS MOTION ABOUT AXES NEAR THE HEAD OF THE PILOT/CONTROLLER FOR A MORE REALISTIC EXPERIENCE, THOUGH A PIVOT POINT BELOW SEAT OR NEAR C.G. MAY WORK FOR SOME APPLICATIONS.



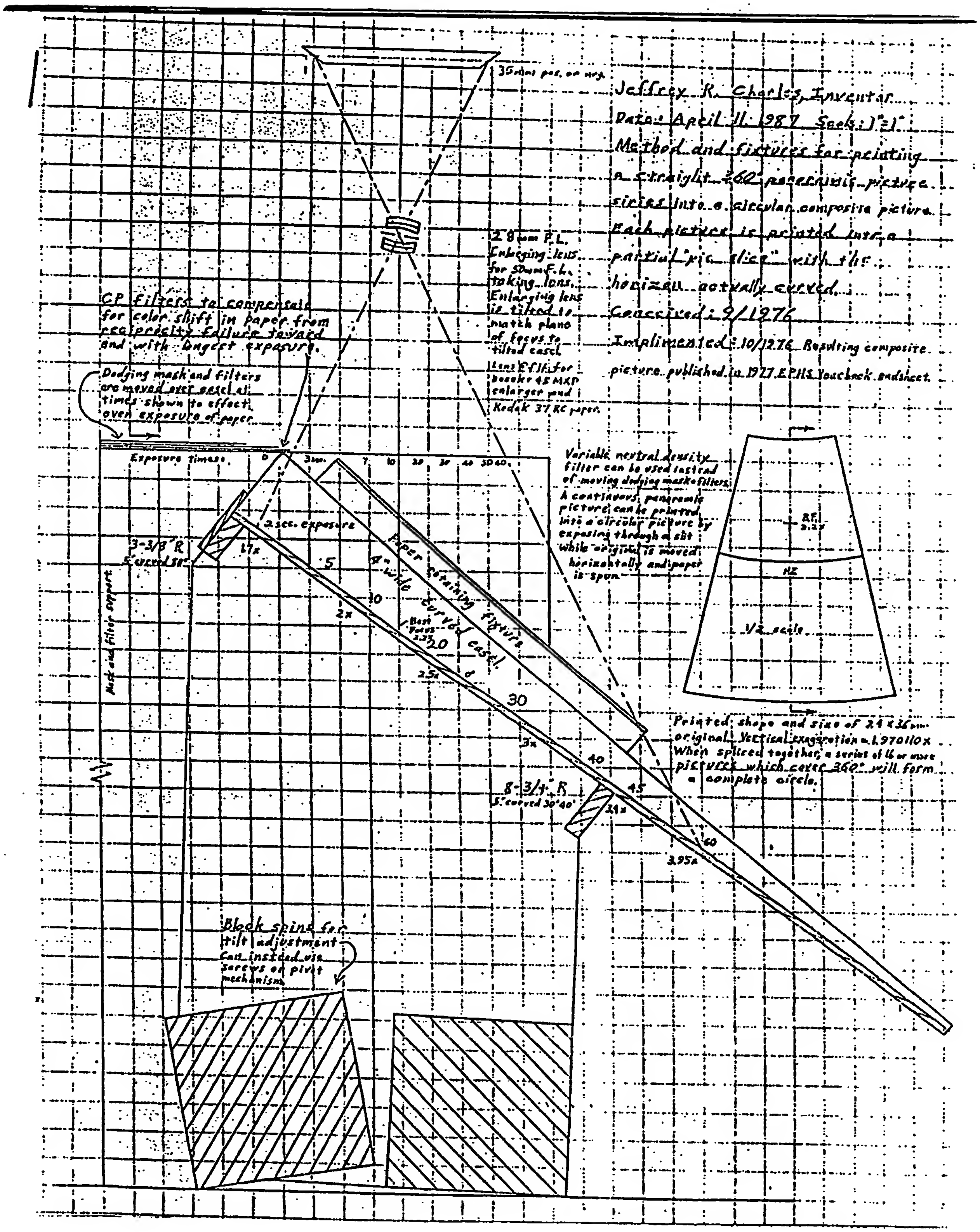
Invention(s): VR PROJECTION SYSTEMS, ETC. SEPARATED PROJECTOR AND REFLECTOR ... | This disclosure and the principles ...

INVENTIONS: FULLY REDUNDANT OMNIDIRECTIONAL IMAGING SYSTEM FOR SIMULTANEOUS CAPTURE OF STEREO OMNIDIRECTIONAL IMAGES. ALSO APPLICABLE TO 3D STEREO OMNIDIRECTIONAL PROJECTION OF VR IMAGES.
FOR SOLAR ECLIPSES, SIMULATIONS, MONITOR AND CONTROL OF OF FLIGHT AND OTHER SYSTEMS. (MANY EMBODIMENTS USE MY AXIAL STRUT REFLECTOR U.S. PATENT NO. D312,263) AND/OR MY SOLID CATADIOPTRIC WIDE ANGLE OPTICAL SYSTEM. (PATENT PENDING) (NOT NECESSARILY SHOWN TO SCALE)
ALL CONCEPTS, DESIGNS, AND METHODS ALSO APPLICABLE TO ORIGINAL PHOTOGRAPHIC OR DIGITAL IMAGING, ETC. AND TO PROJECTION OF PHOTOGRAPHIC, HOLOGRAPHIC, HYBRID, OR COMPLETELY COMPUTER GENERATED GRAPHICS.

VERSACORP
JEFFREY R. CHARLES
9 AUG, 1997 REVISED AS NOTED.
TOTAL VR (TM), TOTAL IMMERSION VR (TM), OMNIPROFLECTOR (TM), IMAGING AND PROJECTION SYSTEMS. IMAGES PRODUCED WITH THESE SYSTEMS AND WITH OMNIRAMA (TM) AND OMNILENS (TM) OPTICS AND/OR TORROIDAL REFLECTORS AND/OR COMPUTER GRAPHICS OR PROCESSING CAN BE PROJECTED WITH WHESE OPTICAL SYSTEMS. THESE SYSTEMS EVEN FACILITATE STEREO PROJECTION FROM SINGLE OR MULTIPLE FILMS, DISPLAY DEVICES, OR A COMBINATION THEREOF.



NG WITH ONE OPTICAL SYSTEM.



35mm pos. or neg.
Jeffrey R. Charles, Inventor
Date: April 11, 1987 Scale: 1"=1"
Method and fixtures for printing a straight 360 panoramic picture series into a circular composite picture.
Each picture is printed into a partial "pie slice" with the horizon actually curved.
Conceived: 9/1976
Implimented: 10/1976. Resulting composite picture published in 1977 EPHS Yearbook endsheet.
28mm F.L. Enlarging lens for 50mm F.L. taking lens. Enlarging lens is tilted to match plane of focus to tilted easel.
CP filters to compensate for color shift in paper from reciprocity failure toward end with longest exposure.
Dodging mask and filters are moved over easel at times shown to effect even exposure of paper.
Exposure times:
2 sec. exposure
Paper retaining fixture
wide curved easel
Best Focus
Variable neutral density filter can be used instead of moving dodging mask+filters.
A continuous panoramic picture can be printed into a circular picture by exposing through a slit while original is moved horizontally and paper is spun.
HZ
1/2 scale
Mask and filter support
3-3/8" R
8-3/4" R
Printed shape and size of 24x36mm original. Vertical exaggeration = 1.970110x
When spliced together, a series of 11 or more pictures which cover 360° will form a complete circle.
Block spine for tilt adjustment. Can instead use screws or pivot mechanism.